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JANUARY
1918

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INSECTS AS CARRIERS OF DISEASE

By Malcolm Evan MacGregor
Wellcome Bureau of Scientific Research

So much has been said about insects since the War began that it is, I think, advisable that some attempt should be made to summarize our knowledge of the more important insect-borne diseases and their vectors. While insects have long been suspected of being responsible for the transmission of serious diseases, it may be said that practically the whole of our knowledge of insects in this rôle has been acquired within the past twenty years. So rapidly, however, has the charge of this offence been made out against them that, although it is common knowledge they have been proved guilty, it is not generally realized upon how many counts the verdict rests.

It has lately been my good fortune to give class instruction for the War Office to officers of the R. A. M. C. who are proceeding to the East, and, in order to bring home to my audience the importance of the connection between insects and disease, I have compiled the tables which I now publish. These can in no way claim to be complete, but merely present the more important insect-borne diseases, including important human diseases that on certain grounds are suspected of having insect vectors. With these tables I also publish one (Table VI) which includes the chief insects and acarina that are directly the cause of disease in man and his domestic animals. To complete the list of insect-transmitted diseases would demand the consideration not only of other mammals as hosts, but also of avian and reptilian hosts. In the present instance this would be to carry the subject beyond general interest, but it must be remembered, therefore, that, long as the present list of charges is, insects are not here arraigned on all the counts that might with justice be preferred against them.

Reprinted from Journal of Tropical Medicine and Hygiene, Sept. 15, 1917; xx, 18.

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During the last few years medical entomology has been rapidly establishing itself an an invaluable branch of preventive medicine, and with the outbreak of the present War a great deal of interest and study has been devoted to this subject in Europe, notably in connection with the transmission of typhus fever by lice, and the dissemination of bacteria and other organisms by flies. Moreover, the importance of insect vectors has been generally realized, and many of the astonishing interactions between pathogenic micro-organisms and certain arthropoda have become popular knowledge.

Centuries ago insects were suggested as being possibly concerned in the spread of disease, and from time to time such logical hypotheses were advanced that it is surprising that the establishment of the truth was not sooner forthcoming. In 1577 Mercurialis, an Italian physician, suggested that plague, which was then ravaging Europe, was spread by flies feeding upon the diseased and dead, and later depositing fæcal matter on food consumed by healthy persons. This idea held ground, and various suggestions occur as to the spread of disease by flies in the literature of the eighteenth century. Edward Bancroft in 1769 advanced the theory that "yaws" was transmitted by flies feeding on diseased subjects, and carrying the contagion by settling on open wounds or scratches on healthy persons.

In 1848 Dr. Josiah Nott, of Mobile, Alabama, published a remarkable article in which he gave reasons for supposing that yellow fever was an insect-borne disease. However, although he mentioned many insects, he did not specify any insect as the particular vector.

The connection between malaria and the mosquito had long been held, it is said, by the Italian and Tyrolese peasants, and even by the natives of East Africa, but the first charge brought against the mosquito in the spread of disease by scientific authority was in connection with yellow fever.

In 1853 Dr. Daniel Beauperthuy, a French physician, wrote ably arguing that yellow fever and other fevers were transmitted by mosquitoes, but in those days there being no accepted belief in a contagium vivum, he concluded that the virus was obtained from decomposing material that the mosquito had consumed, and which

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was later accidentally inoculated into man. Raimbert in 1869 showed by experiment that anthrax could be disseminated by flies.

Epoch-making in the history of our knowledge of insect vectors was Manson's discovery in 1878 that *Filaria bancrofti* was spread by mosquitoes, but at first he thought the *filariæ* escaped from the insect into water, and reached man in this manner. Later work by Manson and his colleagues determined the exact means of transmission.

It was not until twenty-eight years after Beauperthuy's theory that Charles Finlay, an American of Havana, in 1881 definitely attributed the transmission of yellow fever to a mosquito of a definite species. He had noticed the connection that seemed to exist between the presence of large numbers of *Stegomyia fasciata* and the prevalence of yellow fever. He then attempted to transmit the disease experimentally by the bites of this mosquito, and although his experiments are open to criticism, there is no doubt that he did succeed in doing so.

Three years later, in 1883, another American, A. F. A. King, advanced the first well formulated mosquito-malaria theory, and in 1898 Ross, in India, demonstrated beyond doubt the important rôle played by mosquitoes in the transmission of malaria.

In 1899 the American Yellow Fever Commission (Reed, Carroll, Lezear, and Agramonte) were sent to Cuba, and were there able to demonstrate with certainty that yellow fever is transmitted by *S. fasciata*.

It is interesting thus to note the almost parallel development in time of our knowledge of two of the most important insect-borne diseases. To deal even briefly with the historical aspects of our knowledge of other diseases tabulated below would be to consume a large amount of space, and the foregoing account will have indicated the path that has led to subsequent discoveries whose histories are readily available.

I will pass, therefore, to a few notes on each of the tables.

Notes to Table I.—Diseases of Unknown Origin

The majority of these diseases are doubtless caused by living viruses; often organisms of ultra-microscopic size, and commonly referred to as "filterable viruses."

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In the case of pellagra it would appear, however, from the most recent work that, although it is still considered by many persons to be a possible insect-borne disease (and, according to Sambon, having a likely vector in either the *Ceratopogoninæ* or *Simuliidæ*), Goldberger in America considers it a disease now certainly attributable to vitamine-starvation through an unbalanced diet. If this is the case, there is no causative organism and no vector, and pellagra should be ruled out of present consideration. The question, nevertheless, is by no means settled.

The virus of acute anterior poliomyelitis is still not isolated with certainty. Flexner and his colleagues have been able to cultivate a filterable micro-organism which produced the disease in experimental animals, and more recently Rosenow and his fellow workers have isolated a polymorphous streptococcus, with which they were also able to produce paralysis in certain animals. Nuzum and Herzog were able to do likewise by a Gram-positive micrococcus isolated from the brain and spinal cord of persons dead from the disease.

Poliomyelitis has been very generally suspected of being transmitted by insects, particularly by *Stomoxys calcitrans* (the stable-fly), fleas, and *Tabanidæ* (gad-flies). Nevertheless, it appears more likely that it has an ærial transmission, infection being acquired through the buccal and nasal mucous membranes.

The causative organism of Rocky Mountain spotted fever, Wolbach claims to have discovered in the bodies of infective ticks (*Dermacentor venustus*).

Notes to Table II.—Diseases of Bacterial Origin

In the majority of cases, diseases of this class have an *indirect* transmission by insects—that is to say, instead of the organism entering the body of the host through inoculation by the bite of an insect (*direct* transmission), the organisms are carried in or on the insect's body, and are deposited by contact on human food or skin abrasions, and in this manner cause infection.

Bacillus tuberculosis may be disseminated by house-flies feeding on infective sputum, as was first shown by Spillman and Haushalter (1887), and subsequently by the investigations of other workers.

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Table I.

The more important Insect-borne Disease of Unknown Origin

N. B.—Names between square brackets = certain vectors; names without square brackets = probable vectors; names followed by ? = possible vectors.

Organism	Host	Disease	Vector
?	Man ...	Dengue (breakbone fever) ...	[Sandflies (Phlebotomus), Mosquitoes. *C. fatigans; S. fasciata*]
?	" ...	Three-day fever, *syns.* "Dog disease," Sandfly fever, Phlebotomus fever	[Sandflies (Phlebotomus), Mosquitoes. *C. fatigans; S. fasciata*]
?	" ...	Yellow fever	[Mosquitoes *(Stegomyia fasciata)*]
?	" ...	Trench fever	Lice ?
? Salivary toxin? ...	" ...	Tick paralysis (American) ...	[Ticks, *(Dermacentor venustus)*]
? Salivary toxin? ...	" ...	Tick paralysis (Australian) ...	[Ticks *(Ixodes ricinus)*]
?	" ...	Rocky Mountain spotted fever	[Ticks *(Dermacentor venustus)*]
?	" ...	Japanese river fever (shima mushi)	[Mites *(Larval trombidiidæ)*] "aka mushi"
?	" ...	Acute anterior poliomyelitis ...	? Many insects have been claimed as vectors, notably *Stomoxys calcitrans?*
?	" ...	Pellagra	? Gnats of the genus Simulium have been claimed?
?	" ...	Typhus fever	[Lice]

Table II.

The more important Insect-borne Diseases of Bacterial Origin

N. B.—Names between square brackets = certain vectors; names without square brackets = probable vectors; names followed by ? = possible vectors.

The word "flies" includes in the main: *Musca domestica, Fannia* sps., *Calliphora* sps., *Lucilia* sps., and *Sarcophaga* sps.

Organism	Host	Disease	Vector
Bacillus anthracis	Man and animals	Anthrax	[Flies], *Tabanidæ? Beetles?*
" *dysenteriæ*	"	Bacillary dysentery ...	[Flies] *(Musca domestica, Calliphora* sps., *Lucilla* sps.)
" *lepræ*	"	Leprosy	Flies? Fleas? Bed-bugs? Skin mites? Mosquitoes?
" *paratyphosus A*	"	Paratyphoid fever ...	[Flies]
" " *B*	"	" " ...	[Flies]
" *pestis*	" and rats ...	Plague	[Fleas]
" *tuberculosis*	" and animals	Tuberculosis	Flies, cockroaches, fleas? Bed-bugs?
Bacillus typhosus	"	Typhoid fever ...	[Flies]
Bartonia bacilliformis x-bodies ...	"	Verruga	[*Phlebotomus verrucum*]
Spirillum choleræ	"	Cholera	[Flies], cockroaches, ants. Although the main channel of infection is the consumption of infected food and water

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With the high vitality and resistance to drying possessed by the *B. tuberculosis,* the possibly long incubation period within the body and the insidious onset of the disease, the danger from *Musca domestica* in this connection is still not sufficiently recognized.

Human infection with plague and typhus has been shown to be acquired principally by the entrance of the virus through skin lesions, the insect vector having been crushed either during or after the act of blood-sucking. The stomach contents or infected excreta may be rubbed into the lesions or gain entry through abrasions caused by scratching.

This, however, does not preclude the possibility of direct infection also occurring, at least sometimes in the case of plague, as the infected flea has the proventriculus occluded by the plague organisms when the flea infection is at its height. Septicæmia following mosquito bites occasionally happens, and as likely as not the pathogenic organisms are introduced when the mosquito bites. Direct transmission by blood-sucking insects may possibly also occur in certain instances in the spread of tuberculosis and leprosy.

If Wolbach's organism (see Table I and notes thereto) is proved to be the cause of Rocky Mountain spotted fever, this will also be a disease of bacterial origin with *direct* transmission through a tick, *Dermacentor venustus.*

Notes to Table III.—Diseases of Spirochætal Origin

With these diseases the usual method of transmission is *direct* —that is to say, through the bites of the insect vectors.

Exceptions occur in the case of relapsing fever transmitted indirectly by lice, and yaws where *Musca domestica* may at times convey the organism from diseased to healthy persons.

Notes to Table IV.—Diseases of Protozoal Origin

Both *direct* and *indirect* methods of transmission by insects occur with diseases of this class. With the intestinal parasites, indirect transmission takes place by the flies feeding on fæces containing the resistant stages (cysts), and later depositing them on human food and drinking water either by regurgitation of the stomach contents, or more often *per anum,* as Wenyon and O'Con-

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TABLE II.—(Continued.)

Organism	Host	Disease	Vector
Micrococcus melitensis	Man and goats ...	Undulant fever; *syns.* Malta fever, Mediterranean fever, Remittent fever	[Flies]. Although the main channel of infection is the consumption of goat's milk
Diplococcus intracellularis	Man	Cerebrospinal fever ...	Flies?
" *pemphigi contagiosi* ...	"	Tropical impetigo ...	[Lice]

TABLE III.

THE MORE IMPORTANT INSECT-BORNE DISEASE OF SPIROCHÆTAL ORIGIN

N. B.—Names between square brackets = certain vectors; names without square brackets = probable vectors; names followed by ? = possible vectors.

The word "flies" includes in the main:—*Musca domestica, Fannia* sps., *Calliphora* sps., *Lucilia* sps., and *Sarcophaga* sps.

Organism	Host	Disease	Vector
Spirochæta carteri	Man ...	Indian relapsing fever	[Lice]
" *duttoni*	" ...	African " " (Tick fever) ...	[Ticks *(O. moubata, O. savigny)*]
" *gallinarum*	Fowls ...	Spirochætosis	[*Argas persicus*]
" *novyi*	Man ...	American relapsing fever	[Lice]
" *pertenuis*	" ...	Yaws (Framboesia)	Flies?
" *recurrentis*	" ...	European relapsing fever	[Lice]. Bed-bugs?
" *berbera*	" ...	North African relapsing fever ...	[Lice]

TABLE IV.

THE MORE IMPORTANT INSECT-BORNE DISEASES OF PROTOZOAL ORIGIN

N. B.—Names between square brackets = certain vectors; names without square brackets = probable vectors; names followed by ? = possible vectors.

The word "flies" includes in the main: *Musca domestica, Fannia* sps., *Calliphora* sps., *Lucilia* sps., and *Sarcophaga* sps.

Organism	Host	Disease	Vector
Entamœba histolytica ...	Man	Amœbic dysentery	[Flies]
*Lamblia intestinalis** ...	"	Flagellate "	[Flies]
Plasmodium malaria ...	"	Quartan malaria	[Anopheline mosquitoes]
" *vivax* ...	"	Benign tertian malaria	[Anopheline mosquitoes]
" *falciparum* ...	"	Malignant or subtertian malaria ...	[Anopheline mosquitoes]

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nor have shown recently.[1] Needless to say, infection also occurs—and perhaps principally—by mechanical and ærial transmission of the cysts to food and water.

The majority of the protozoal blood parasites have insect vectors, on which they depend solely for transmission, and in certain cases these vectors are specific: Malaria, *Anophelines;* sleeping sickness, *Glossinæ;* European relapsing fever, *Pediculi.* Other insect-borne blood parasites are apparently able to be transmitted by more than one vector, i. e., Kala-azar, bed-bug (Patton); kala-azar, *Triatoma rubofasciatus* (Donovan); Souma (*Trypanosomiasis*), *Glossinæ;* Souma (*Stomoxys calcitrans*).

Notes to Table V.—Diseases of Helminthal Origin

With the exception of possible infection with certain helminths, resulting from the carriage by flies of helminth ova from fæces and subsequent deposition of the ova on food, the insect-borne helminths all undergo part of their life-history in the body of the insect vector. Thus the adult *Filaria bancrofti* live in human lymphatic glands. The ova find their way into the blood-stream, where they hatch to the Microfilariæ, and some are taken up from the blood when a mosquito bites a person harbouring the organisms. These, if they have entered the stomach of *Culex fatigans,* or other intermediate host, soon make their way to the thoracic muscles of the mosquito, where they undergo definite metamorphosis. When this is complete (usually in from sixteen to twenty days) the worms make their way into the mosquito's proboscis, and when next it pierces the skin of some victim the filariæ burst through the proboscis sheath and make their own passage through the skin, from which they soon travel to some lymphatic gland, where they become sexually mature, and the cycle is repeated. Similarly, *Dipylidium caninum* passes part of its life-history in the rat flea, and becomes sexually mature in the dog or man. The ova are ingested by the larval flea, and infection by the cysticercoid stage follows the accidental ingestion of the flea by the definite host.

[1] "The Carriage of Cysts of *Entamœba histolytica* and other protozoa, and eggs of Parasitic Worms by House-flies, with some Notes on the Resistance of Cysts to Disinfectants and other Agents." C. M. Wenyon and F. W. O'Connor, *Journal of the Royal Army Medical Corps,* May, 1917, p. 522.

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TABLE IV.—(Continued.)

Organism	Host	Disease	Vector
Leishmania tropica	"	Oriental sore	Flies? Fleas? Phlebotomus? Hippobosca?
" *donovani*	"	Kala-azar	Bed-bugs? Fleas? Triatoma?
" *sp. incerta*	"	Espundia	Probably some tropical blood-sucking insect
" *infantum*	Children	Leishmaniasis	Fleas?
Trypanosoma gambiense	Man	Sleeping sickness	[*Glossina palpalis* (Tsetse flies)]
" *rhodesiense*	"	" "	[*Glossina morsitans*] " "
" *brucei*	Cattle and horses	Fly sickness (Nagana)	[*Glossina morsitans*] " "
" *lewisi*	Rats	Rat trypanosomiasis	Rat louse? and [Rat fleas *(Ceratophyllus fasciatus), Ctenocephalus canis*]
" *evansi*	Horses, mules, camels	Surra	[Horse flies (Tabanidæ), *Tabanus striatus*]
Schizotrypanum cruzi	Man	Chaga's disease	[*Triatoma* (Conorhinus) *megistus*]
Babesia bigeminum	Cattle	Red-water fever	[Ticks *(Margaropus annulatus)*]
" *ovis*	Sheep	Piroplasmosis	[Ticks *(Rhipicephalus bursa)*]
" *canis*	Dogs	Malignant jaundice	[Ticks *(Rhipicephalus sanguineus* and *Hæmaphysalis leachi)*]
" *caballi*	Horses and mules	Piroplasmosis	[Ticks *(Dermacentor reticulatus)*]
Nuttallia equi	" "	"	[Ticks *(Rhipicephalus evertsi)*]
? Chlamydozoa ?	Man	Ophthalmia ægyptica and other ophthalmic conditions	[Flies]

*By some authorities *Lamblia intestinalis* is not regarded as pathogenic.

TABLE V.

THE MORE IMPORTANT INSECT-BORNE DISEASES OF HELMINTH ORIGIN

N. B.—Names between square brackets = certain vectors.

The word "flies" includes in the main: *Musca domestica, Fannia* sps., *Calliphora* sps., *Lucilia* sps., and *Sarcophaga* sps.

Organism	Host	Disease	Vector
Dipylidium caninum	Man and dogs	Tæniasis (tapeworm)	[Dog louse *(Trichodectes latus)*]; [Dog flea *(Ctenocephalus canis)*]; and the [Human flea *(Pulex irritans)*]
Ova of certain helminths	Man	Helminthiasis (parasitic worms)	[Flies]
Microfilaria bancrofti	"	Filariasis (Elephantiasis)	[Mosquitoes *(Culex* and *Anopheles* sps.)]
Loa loa	"	Calabar swellings	[Horse flies *(Chrysops dimidiata* and *Chrysops silacea)*]
Filaria immitis	Dogs	Dog filariasis	[Mosquitoes *(Culex* and *Anopheles* sp.)]
Hymenolepis diminuta	Rats, and occasionally man	Tæniasis	[Fleas]

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Table VI.

The more important Diseases directly attributable to Insects and Acarina

N. B.—Name between square brackets = certain vector.

Organism	Host	Disease	Vector
The larvæ of *Fannia canicularis* ...	Man	Intestinal myiasis	—
" " *Piophila casei* ...	"	" "	—
" " *Eristalis tenax* ...	"	" "	—
" " *Muscina stabulans* ...	"	" "	—
" " *Sarcophaga* sps. ...	"	Intestinal, dermal and muscular myiasis	—
" " *Lucilia* sps. ...	"	" " " " "	—
" " *Calliphora* sps. ...	"	" " " " "	—
" " *Chrysomyia macellaria* (the Screw worm)	" and animals ...	Nasal, auricular, and dermal myiasis ...	—
" " *Cordylobia anthropophaga* (the Tumbu fly)	Man	Dermal myiasis	—
" " *Dermatobia hominis* ...	"	" "	[Mosquito (*Janthinosoma lutzii*)]
" " " " ...	"	" "	
" " *Hypoderma bovis*, &c. ...	Cattle (occasionally man)	" " (Creeping disease in man)	—
" " *Œstrus ovis*	Sheep (rarely man)	Nasal myiasis	—
" " *Gastrophilus equi*, &c.	Horses	Gastric myiasis	—
" " *Trombidiidæ* (Harvest mites)	Man	Severe cutaneous irritation	—
Pediculoides ventricosus	"	Dermatitis	—
Tyroglyphus siro	"	" (the so-called "vanillism") ...	—
Other *Tyroglyphidæ* ...	"	" (Grocers' itch)	—
Tyroglyphus longior castellani ...	"	Copra itch	—
Sarcoptes scabiei	" and animals ...	"Itch" or "scabies"	—
Pediculus capitis	Man	Pediculosis of the head	—
" *humanus*	"	" " body	—
Phthirius pubis	"	" " axillary and pubic regions	—
Dermatophilus penetrans (Chiggers)	" and animals ...	Severe cutaneous irritation	—

The more important Insect-borne Diseases of Fungus Origin

N. B.—Name between square brackets = certain vector.

Organism	Host	Disease	Vector
Achorion schonleinii ...	Man ...	Favus ...	[Lice (Pediculi)]

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Notes to Table VI.—Diseases Directly Attributable to Insects and Acarina

In each case the disease results from the damage done by the insects and acarina in adopting existence upon the body of the host and living upon its tissues. The time spent upon the host may cover the whole life-history of the parasite and many subsequent generations, as with *Sarcoptes scabiei* and the *Pediculi,* or it may only embrace part of the parasite's development, as with the larvæ of flies causing myiasis. In either case the injury to the host may be so extensive as to cause death from the loss of vital tissue, or the injury itself, although insignificant, may indirectly cause death to the host by providing a suitable path for invasion by pathogenic micro-organisms.

Conclusion

It should be borne in mind that a large number of diseases included in the foregoing tables are not confined to being spread by insects, and insect transmission may in some cases only be occasional. This fact, however, cannot afford the preclusion of such diseases from consideration, and where transmission of the indirect type is possible, it is obvious that we are unable to form any just estimate of its relative importance. Probably, nevertheless, the dissemination of pathogenic micro-organisms by flies, for all that has lately been said in this connection, has not even yet been over-emphasized. It seems more than likely that *Bacillus tuberculosis* is spread in this manner from infective sputum to food (milk particularly) to a much greater extent than is commonly imagined, and there being no probability of rapid acute infection, as with *B. typhosus,* the part played by the fly is too apt to be overlooked.

Much of our knowledge with regard to insects and disease is still indefinite, as may be seen from the tables, but to anyone not particularly conversant with the subject, what we already know with certainty, even in connection with only the more important diseases that have been considered, may be sufficient to cause some little surprise.

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THE ACANTHOCEPHALA OF NORTH AMERICAN BIRDS*

H. J. Van Cleave

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I. Introduction

Parasitologists have given little attention to the Acanthocephala parasitic in North American birds. The result has been a rather general belief that infestation with Acanthocephala in this class of vertebrates is rare. It is true that heavy infestations are more commonly found in other groups of vertebrates, but many of the

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water and shore birds carry very heavy infestations of Acanthocephala. Among the land birds, while infestation is not rare, it is usually of less frequent occurrence, and the number of parasites found in a single host individual is usually smaller. Most of the earlier records of the occurrence of Acanthocephala in North American birds ascribe the forms found to known European species. This is not surprising when one reviews the extent to which the study of Acanthocephala in birds has proceeded in Europe. Yet the mere fact that all earlier writers recognized but the one genus, Echinorhynchus, in part explains their lack of appreciation of specific characters within this group. On the whole, most of the earlier specific descriptions are little more than sufficient to permit of later workers recognizing the genus to which the species belong. This lack in specificity of earlier descriptions quite naturally lead the new world investigators to believe that the species they found on this continent were the same as the European species, since the descriptions published contained insufficient data to permit of a separation.

As indicated by the writer in an earlier paper (Van Cleave 1916 b: 228), the acanthocephalan fauna of North America is in the main a distinctive fauna with few species identical with those of the European fauna. The attempt on the part of earlier parasitologists to ascribe names of European species to forms found on this continent has, to a great extent, hindered the appreciation of this distinctness of the North American fauna, and at the same time has lead to considerable confusion regarding the geographical distribution of the genera and species of Acanthocephala. Unfortunately, many of the specimens of the older writers are not available for restudy to determine the correctness of the original determinations. However, in most cases where further study has been possible points of difference from the European species have been found too numerous to permit of including the American forms in the European species.

The writer has made an extensive study of the Acanthocephala of birds in which he has had access to the collections of the U. S. Bureau of Animal Industry, the U. S. National Museum, the Marine Hospital Service, private collections of Dr. H. B. Ward and of the

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writer. Papers covering the species of several genera of Avian Acanthocephala have already been published by the writer as a result of the study of these collections. The present article deals with the descriptions of several new species and a reconsideration of some forms previously described, but here for the first time ascribed to the proper genera as recognized by more recent developments of classification of the Acanthocephala. In all cases the study has been made from cleared, stained specimens mounted in damar.

Linton (1892: 92) recorded the occurrence of *Echinorhynchus striatus* Goeze from the intestine of the black scoter, *Oidemia americana,* collected at Yellowstone Lake, Wyoming. The writer has reexamined the original material of this collection and finds that these individuals constitute an undescribed species of the genus Corynosoma. Linton (page 92) remarked that the two females constituting the extent of the infestation of one of the hosts differed from the six males from the other host individual, in the "absence of spines at the posterior end" of the former. It is true that this sexual dimorphism is characteristic of the members of the genus Corynosoma as indicated by the founder of the genus, Lühe (1904 and 1911).

Of the materials from this collection deposited in the U. S. National Museum, one entire female, a portion of a second and five of the males, have been studied by the present writer. The entire female specimen is immature but, fortunately, the fragment of a specimen is of the anterior end of a fully mature individual so that the body cavity contains well developed embryos.

II. The Genus Corynosoma Lühe, 1904

The genus Corynosoma was established by Lühe to accommodate two species of Acanthocephala parasitic in fish-eating mammals and birds. This genus is characterized by the presence of spines on the anterior end of both sexes while in addition the males bear spines around the genital opening. The body is swollen anteriorly and with its coating of spines adheres to the intestinal mucosa of the host thereby furnishing an accessory means of attachment. Posteriorly the body gradually becomes smaller.

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Corynosoma constrictum nov. spec.

Plate I, Figures 1, 2 and 3

Synonym: *Echinorhynchus striatus* Goeze of Linton 1892.

SPECIFIC DEFINITION. With the characters of the genus. Body of the males 2.28 mm. to 4.3 mm. long, with a maximum diameter of from 0.5 mm. to 0.6 mm. Linton gives the measurement of a female 3.3 mm. long with a diameter of 0.8 mm. Proboscis slightly larger at base than at tip, armed with sixteen longitudinal rows of ten to twelve hooks each. Hooks near base of proboscis 0.035 to 0.041 mm. long, near middle of proboscis 0.041 to 0.047 mm. long, near tip of proboscis 0.030 to 0.041 mm. long. A constriction occurs around the body at about the anterior third (see Fig. 1). In both sexes the part of the body wall anterior to this constriction is armed with small cuticular spines about 0.030 mm. long. Each of these spines is embedded in a triangular elevation of the cuticula projecting from the general body surface. In the males there occurs in addition a group of cuticular spines surrounding the genital opening (Fig. 2). The genital spines are of the same size as those on the anterior region of the body, usually with the tip strongly recurved. Embryos in body of female 80 to 108μ long by 12 to 16μ wide (Fig. 3).

Type host *Oidemia americana,* in intestine. Type locality Yellowstone Lake, Wyoming. The cotypes of this species are deposited in the Smithsonian Institution; the males under catalog number 5449 and females under number 5439.

III. The Genus Plagiorhynchus Lühe, 1911

In the same paper mentioned above (1892: 91) Linton described another species of Acanthocephala from the intestine of a gull taken at Guaymas, Mexico. To this new species, founded on the study of one male and one female, he gave the name *Echinorhynchus rectus*. The present writer has examined the female of this collection, the only specimen in the bottle of material turned over to him for study from the collections of the U. S. National Museum. Facts brought out by the reexamination of the female of this species and the study of Linton's description of the male and female clearly indicate that this species belongs in the genus Plagiorhynchus, which

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up to the present time has not been recorded as occurring in North America. In the present paper the writer describes still another species belonging to the genus Plagiorhynchus.

CHARACTERS OF THE GENUS PLAGIORHYNCHUS. Acanthocephala belonging to this genus are parasitic as adults in the alimentary canal of birds. The proboscis is cylindrical with numerous hooks arranged in radial symmetry. The body proper, which is entirely devoid of spines, is usually short, elliptical, or with a tendency toward egg-shaped. The proboscis receptacle is a double walled muscular sac attached at the base of the proboscis. In dealing with other genera of Acanthocephala the writer has found that in Arhythmorhynchus (Van Cleave 1916:a) the embryos in recently discovered American species differ in appearance from those described for European species of obviously the same genus. Here again in the genus Plagiorhynchus Lühe (1911:27) described embryos and figured one having the middle membrane with a conspicuous spherical knob at each of its two poles. This he considered characteristic of the entire genus (1911:26). The embryos of *P. formosus* (Fig. 6) are elliptical with no polar knobs. Here is evidence, in addition to that previously brought out by the writer (1916:a) and mentioned above, regarding the advisability of omitting the shape of the embryonic shells from the generic diagnosis.

Lühe (1911:26) specified the presence of six closely compacted, thickset, cement glands as characteristic of the genus Plagiorhynchus. In earlier papers (1914 and 1916) the present writer has shown that shape and number of cement glands may both vary widely among different species of the same genus. Consequently I propose that a fixed number of cement glands and the shape of the cement glands be omitted from the list of characters diagnostic of this genus. Descriptions of two species, one new, and the other newly attributed to this genus follow.

Plagiorhynchus rectus (Linton, 1892)

Plate I, Figure 7

Synonym, *Echinorhynchus rectus* Linton, 1892

Described originally from one male and one female of which the female only has been reexamined by the present writer. Body

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of female 9 mm. long and 0.8 mm. in diameter. Proboscis cylindrical, 1.9 mm. long; 0.26 mm. in diameter; armed with twenty-four longitudinal rows of about twenty hooks each. In specimen examined this last number was calculated on the basis of the number of hooks on the exposed portion of the proboscis, since the tip of the proboscis is inverted. Hooks near the base of the proboscis 0.082 mm. long, with a diameter of 0.016 mm. at the point of emergence from proboscis wall; hooks near middle of proboscis 0.070 mm. long, recurved, with a diameter of 0.020 mm. at the point where the hooks curve backward; hooks near tip of proboscis 0.053 mm. long. Male 8.8 mm. long and 0.8 mm. in diameter. Testes oval, approximate, median. Female not fully mature so measurements of embryos cannot be given.

Type host, Larus (Chroicocephalus) sp. taken at Guaymas, Mexico. Type female deposited in U. S. National Museum, catalog number 5431.

Plagiorhynchus formosus nov. spec.

Plate I, Figures 4, 5 and 6

SPECIFIC DEFINITION. With the characters of the genus. Body about 10 mm. long, elliptical to slightly ovoid. Proboscis practically cylindrical, diameter about one-third of length; armed with sixteen longitudinal rows of thirteen to fourteen hooks each. Cement glands long, tubular. Hard shelled embryos inside body of female elliptical, 48 to 60μ long by 12 to 20μ in diameter.

This species is described from four mature individuals, two males and two females, in the Parasite Collection of the U. S. Bureau of Animal Industry; catalog number 4598. The writer designates one male and one female as types of the species. Descriptions of these follow.

TYPE MALE. Body elliptical with anterior and posterior extremities slightly flexed ventrally; entire length 8.5 mm.; maximum diameter 2 mm. Body proper devoid of spines. Proboscis subcylindrical, length 1.06 mm., diameter 0.33 mm., armature as mentioned in definition of species. The following table of measurements of hooks in a single row from tip to base of proboscis indicates relative size of hooks in various regions of proboscis.

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Row	1	2	3	4	5	6	7	8	9	10	11	12	13	
Length in μ	71	77	83	83	83	83	83	83	83	77	77	77	65	Base

Proboscis receptacle cylindrical, 1.73 mm. long, 0.42 mm. in diameter, base of the receptacle rounded, with invertors of proboscis penetrating posterior extremity (Fig. 4). Brain 0.180 mm. long, in center of proboscis receptacle, between the invertors. Retinacula conspicuous at the middle of the proboscis receptacle. Lemnisci 0.192 mm. long, 0.058 mm. in diameter. Anterior and posterior testes form an oblique line of contact; each 1.15 mm. long and 0.6 mm. in diameter. Cement glands long, tubular, extending from the dorsal margin of posterior testis to region of bursa.

TYPE FEMALE. Body more nearly cylindrical than type male, 9.5 mm. long, 2 mm. in diameter. Tip of proboscis slightly inverted, size and aramture practically identical with that described for male. Body filled with developing embryos surrounding and covering almost all of internal organs. Hard shelled embryos within type female rather variable in size, 40 to 60μ long by 12 to 20μ in diameter.

Type host, the flicker, *Colaptes auratus,* in intestine. The four specimens upon which the species is founded were collected at Bowie, Maryland, October 9, 1906, by Dr. B. H. Ransom.

MORPHOLOGY. The males of this species display a phenomenal transparency of body structures so that in stained whole mounts minute internal structures are observable with the greatest ease. The proboscis in the preserved specimens is so inserted that it points ventrally at an angle of approximately 60 degrees from the chief axis of the body. At the base of the proboscis the body proper is slightly expanded to form a thickened rim. The proboscis receptacle is a cylindrical sac composed of two muscular layers. The retinacula arise in the brain as two fairly small fibres. Upon penetration of the wall of the receptacle their size increases appreciably. This increased size is maintained through the remainder of their course to their insertion upon the body wall. The means of insertion upon the wall of the body is shown in Fig. 4. The lemnisci are slightly longer than the proboscis receptacle and of smaller diameter throughout.

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The two testes of the male are roughly oval, lying in the anterior region of the body. Lühe (1911:26) described six closely compacted cement glands as characteristic of the genus Plagiorhynchus. *P. formosus* appears to have six of these glands (Fig. 4), but their shape differs radically from the shape of the cement glands of *P. lanceolatus*.

The hooks upon the proboscis present a perfect pattern in their exact arrangement in alternating rows. Roots of the hooks are not distinct. The base of each hook for a length of about 0.021 mm. lies embedded in the wall of the proboscis perpendicular to its surface. The free portion of each hook is directed backward at an angle of about 110 degrees with the basal portion. The foregoing description of hooks applies to all hooks upon the proboscis except one or two hooks at the base of each row, which are simple, thorn-like and one or two of those at the tip of the proboscis which differ from the remaining hooks in shape and general proportions (see Fig. 5). In all cases measurement of hooks here as in other papers by the writer the length of a hook is considered as the straight line connecting the tip of the hook with its extreme basal part.

IV. The Genus Polymorphus Lühe, 1911

Acanthocephala parasitic as adults in the intestine of birds. Posterior tip of the body rather broadly truncated. Anterior end of body swollen and separated from more attenuated posterior region by a constriction. Anterior region of the body spined. Proboscis usually cylindrical, frequently smaller at base.

Polymorphus obtusus nov. spec.

Plate II, Figs. 8, 9, 10, 11, and 12

Body with a slightly enlarged anterior region. This enlargement is set off by a constriction back of which the body again assumes a diameter equal to that of the anterior enlargement, then gradually decreases in size to the posterior tip which is more or less flexed ventrally. Posterior tip terminates bluntly (Fig. 11). Females 7.7 mm. long, males 4 to 5.5 mm. long. Proboscis in all specimens examined partially inverted, armed with about sixteen longitudinal rows of hooks. Anterior body region armed with small

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cuticular spines about 24μ long (Fig. 9). Embryos within body of female 60 to 80μ long and 20 to 24μ wide with one conspicuous outpocketing of the middle membrane at each pole (Fig. 10).

Type host *Anhinga anhinga* (water-turkey), in intestine. Type locality, Florida. Described from three specimens, one female and two males. Cotypes in U. S. National Museum, catalog number 2967.

Polymorphus sp?

Plate II, Fig. 13

In addition to *Polymorphus obtusus* another representative of this genus has been studied by the writer, but the single specimen, a male, is insufficient to permit of a description of the species. Record is given here with a drawing of the proboscis in order to facilitate comparison in case other specimens are found from the same host later. The host of this undescribed species in the hooded merganser, *Lophodytes cuculatus*. Specimen in the U. S. Bureau of Animal Industry Collection, catalog number 2808.

V. The Genus Centrorhynchus Lühe, 1911

Centrorhynchus spinosus Van Cleave, 1916

Plate III, Figs. 14 and 15

A single species of this genus has been described from North America. The writer (1916b) described *C. spinosus* from the intestine of the egret, *Herodias egretta*. For description see paper cited above.

VI. The Genus Mediorhynchus Van Cleave, 1916

Mediorhynchus papillosus Van Cleave

Plate III, Figs. 16, 17, 18 and 19

Mediorhynchus robustus Van Cleave, 1916

Plate IV, Figs. 20 and 21

This genus, which to the present time has been recognized only from North America, was created by the writer (Van Cleave 1916b) for three new species of Acanthocephala belonging evidently near to the genus Centrorhynchus, but having characteristics which

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prevented including them in that genus. At the time the description of this genus was published the writer failed to designate which of the species should be considered as type. *M. papillosus* is hereby designated as type of the genus Mediorhynchus.

Mediorhynchus papillosus has been recorded from *Myiochanes virens* (the wood pewee) and *Porzana carolina* (the sora). *Mediorhynchus robustus* has been found in *Icteria virens* (the yellow-breasted chat).

Mediorhynchus grandis was originally included within this same genus but a more thorough study of Kostylew's articles dealing with the genus Heteroplus has convinced the writer that the species *grandis* is, in reality, a member of the genus Heteroplus. Kostylew (1913: 532) considered Heteroplus as near to the genus Gigantorhynchus from which he claimed to have separated it. On the other hand de Marvel (1905: 217) considered *Echinorhynchus otidis,* one of the species upon which Kostylew founded his genus Heteroplus, as a synonym for *E. aluconis. E. aluconis,* through the careful work of Lühe (1911), became type of the genus Centrorhynchus. At the same time *Gigantorhynchus mirabilis* de Marvel, which Kostylew claimed also belonged to his genus Heteroplus, is clearly, on the basis of de Marvel's descriptions and figures, one of the Centrorhynchidæ. De Marvel's figures show clearly the constriction of the proboscis at the line of insertion of the receptacle with the coincident differentiation of hooks on the anterior and posterior regions of the proboscis. Kostylew (1913), in describing the proboscis receptacle of Heteroplus, referred to the anterior half as being twice the diameter of the posterior half. This condition is typical of the genus Mediorhynchus and serves as an additional argument for considering the genus Heteroplus as a member of the family Centrorhynchidæ and not of the Gigantorhynchidæ.

VII. The Genus Heteroplus Kostylew, 1914

With the characteristics of the family Centrorhynchidæ. Anterior and posterior regions of the proboscis bearing widely different numbers of longitudinal rows of hooks.

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Heteroplus grandis (Van Cleave, 1916)
Plate V, Figs. 27, 28 and 29
Synonym, *Mediorhynchus grandis* Van Cleave, 1916

This species, the description of which is given in Van Cleave 1916 b: 226, was described from *Quiscalus quiscula* (the purple grackle) and *Sturnella magna* (the meadow lark). More recently the writer has examined a specimen from *Corvus brachyrhynchus* (the crow) taken in Maryland which proves to belong to this same species.

Kostylew's contention that the genus Heteroplus belongs to the Gigantorhynchidæ caused the writer at the time of the description of this species to believe that its superficial and general resemblance to Heteroplus was not of great significance.

VIII. The Genus Filicollis Lühe, 1911

Filicollis botulus Van Cleave, 1916
Plate V, Figs. 30, 31, 32, 33 and 34

But a single species of this genus, *F. botulus,* has been recorded from North America. This species differs widely from *F. anatis* of Europe, especially in the shape of the proboscis of the female. Specific characteristics upon which this species was founded are given in an earlier paper (Van Cleave 1916). Since the species was described the writer has discovered younger males than he had seen at the time of the original description. Figure 30 shows the arrangement of the internal organs of one of these young males. The eider ducks, *Somateria dresseri* and *S. mollissima,* are the known hosts of the species.

IX. The Genus Arhythmorhynchus Lühe, 1911

Arhythmorhynchus uncinatus (Kaiser, 1893)
Arhythmorhynchus trichocephalus (R. Leuckart, Kaiser, 1893)
Arhythmorhynchus brevis Van Cleave, 1916
Plate IV, Figs. 22, 23 and 24
Arhythmorhynchus pumilirostris Van Cleave, 1916
Plate IV, Figs. 25 and 26

Kaiser in 1893 published a description of *Echinorhynchus uncinatus* Kaiser and *E. trichocephalus* R. Leuckart. The writer

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(1916a: 172) showed that these two species belong in reality to the genus Arhythmorhynchus and in the same paper described two additional species for this genus, *A. pumilirostris* and *A. brevis,* both from the intestine of the American bittern, *Botaurus lentigenosus.*

X. Species Inquirendæ and Species of Doubted Determination

Echinorhynchus pici collaris Leidy, 1850

Leidy described and recorded the occurrence of four Acanthocephalans from North American birds, but no one of these is the present writer able to locate with any degree of certainty within the modern system of classification of the group. The description of *Echinorhynchus pici collaris* from *"Picus colaris"* is lacking in details sufficient to permit of speculation as to even the genus to which it belongs. Consequently *E. pici collaris* must be regarded as a *species inquirenda.* The other three species, given the names of known European species, probably belong to the respective genera now recognized as including the European forms.

(?) *Echinorhynchus caudatus* Zeder of Leidy 1887

This species, which Leidy recorded from *Elanoides forficatus* and from *Scotiaptex nebulosa,* has been considered by the present writer (1916 b: 222) as belonging to the family Centrorhynchidæ, though the original description is insufficient to permit of a closer determination. It is extremely improbable that Leidy's determination of this species is correct.

(?) *Echinorhynchus striatus* Goeze of Leidy 1856

From the intestine of *Mycteria americana* (*"Tantalus loculator"*), the wood ibis, Leidy recorded the occurrence of *Echinorhynchus striatus* Goeze. Lühe (1911) was unable to place Goeze's *E. striatus* in his revised system of classification. It seems improbable that Leidy was dealing with the species which Goeze described from central Europe. Many points of detail have caused the present writer to consider the form which Leidy recorded as probably one of the species of Arhythmorhynchus. Its relations to other species of this genus cannot be determined.

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(?) *Echinorhynchus hystrix* Bremser of Leidy 1887

Leidy's report of *Echinorhynchus hystrix* from *Anhinga anhinga* (the water turkey) gives some ground for attributing the genus Corynosoma as parasitic upon that species of bird, though here again the specific identity with the European form is to be seriously doubted.

XI. Distribution of the Acanthocephala of Birds

It seems worth while to call attention to the fact that in the collections from birds examined by the writer the occurrence of two different species of Acanthocephala within the same host individual has never been observed. Furthermore there is no positive case on record wherein two different genera of Acanthocephala have been found in the same species of North American bird. The case of *Anhinga anhinga* seems to be an exception to this last statement. From this host the writer has described a species of Polymorphus while Leidy has described what seems to be a species of Corynosoma. However in general body form these two genera resemble one another closely enough to confuse the casual observer. On this basis the apparent exception to the general condition may not be a real one.

De Marval, in his significant monographic contribution to the study of Avian Acanthocephala, has unfortunately failed to furnish us with any considerable body of data upon the geographical distribution of the species with which he worked. Evidently many of his records are compilations from earlier writers. In his treatment of each species of Acanthocephala he has given a host list, but offers no information as to the locality from which the hosts were taken. A study of his data shows that he has recorded the occurrence of Acanthocephala in more than forty families of birds representing eleven of the seventeen orders of birds recognized in North America and in addition some families not represented in the North American fauna.

In the collections available to the writer these parasites have been found in but seven orders, and a total of but ten families of birds. Beyond this Leidy's reports indicate the presence of Acanthocephala in at least three additional families. It is a noteworthy

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fact that the geographical distribution of the species known to North America is restricted almost exclusively to the eastern part of the continent. In the opinion of the writer this apparent localization of infestation is probably due to the fact that records from the West are wanting rather than that the actual distribution is so narrowly limited. Much of the materials studied by the writer has been the result of the careful work of Mr. Albert Hassall.

XII. Distribution of Genera of Acanthocephala in Families of European and North American Birds:

Family of Birds Acting as Host	Genera of Acanthocephala Reported from Central Europe (Lühe 1911)	Genera of Acanthocephala Reported from North America
Colymbidæ	Filicollis	
Laridæ	Filicollis	Plagiorhynchus
Anhingidæ		Polymorphus
		?Corynosoma
Anatidæ	Polymorphus	Polymorphus
	Filicollis	Filicollis
	Corynosoma	Corynosoma
	?Centrorhynchus?	
Ciconiidæ		?E. striatus?
Ardeidæ	Filicollis	Centrorhynchus
	?Arhythmorhynchus?	Arhythmorhynchus
Rallidæ	Polymorphus	Mediorhynchus
	Filicollis	
Scolopacidæ	Plagiorhynchus	
	Arhythmorhynchus	
	Filicollis	
Charadriidæ	Plagiorhynchus	
	Polymorphus	
Buteonidæ		?E. caudatus?
Falconidæ	Centrorhynchus	
Strigidæ		?E. caudatus?
Picidæ		Plagiorhynchus
		?E. pici collaris?
Tyrannidæ		Mediorhynchus
Corvidæ		Plagiorhynchus
		Heteroplus
Icteridæ		Heteroplus
Mniotiltidæ		Mediorhynchus

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In the above table genera and species marked with a question mark (?) are of questioned original determination or are *species inquirendæ*. It is quite a striking fact that in only the family Anatidæ and probably the Ardeidæ are any of the same genera of Acanthocephala found in both North America and Europe.

Lühe (1911), in his register of the Acanthocephala and parasitic flatworms from central European hosts recorded the occurrence of Acanthocephala from hosts representing but eight families of birds. The accompanying table based upon Lühe's data and records of the writer shows in striking manner the differences between the types of hosts characteristic of the various genera in Europe and North America. To the writer this table furnishes still farther evidence of the independence of the acanthocephalan fauna of the two continents. In the majority of cases even the genera of these parasites have found hosts in entirely different Families and even Orders of birds.

XIII. Genera of Acanthocephala with the Orders of Birds From Which Taken

Genus of Acanthocephala	Order of Birds Serving as Host: Central Europe (Lühe)	Order of Birds Serving as Host: North America
Arhythmorhynchus	Limicolæ	Herodiones
Centrorhynchus	Raptores Anseres	Herodiones
Corynosoma	Anseres	Anseres ?Steganapodes
Filicollis	Anseres Pygopodes Longipennes Herodiones Paludicolæ Limicolæ	Anseres
Heteroplus		Passeres
Mediorhynchus		Passeres Paludicolæ
Plagiorhynchus	Limicolæ	Pici Longipennes Passeres
Polymorphus	Limicolæ Anseres Paludicolæ	Steganapodes Anseres

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A comparison of infestation within the *Orders* of birds furnishes a contrast between the two continents even more striking than that found in the comparison of the Families of birds. The accompanying table shows among other things, that Corynosoma, Filicollis and Polymorphus are the only genera having hosts within the same orders of birds on the two continents.

XIV. Key to the Genera and Species of Acanthocephala of North American Birds

1 (12) Acanthocephala with body proper devoid of spines..... 2

2 (5) Proboscis receptacle inserted at base of proboscis..... ..... Genus PLAGIORHYNCHUS.. 3

3 (4) Twenty-four longitudinal rows of hooks..... ..... *Plagiorhynchus rectus.* Linton

4 (3) Sixteen longitudinal rows of hooks..... ..... *Plagiorhynchus formosus* nov. spec.

5 (2) Proboscis receptacle inserted at or near middle of proboscis. Proboscis hooks anterior to and posterior to insertion conspicuously unlike 6

6 (7) Invertors of proboscis extending through posterior tip of proboscis receptacle and continuing as retractors for receptacle..... .....Genus CENTRORHYNCHUS

Centrorhynchus spinosus Van C., only known species in North America.

7 (6) Invertors of proboscis passing through wall of proboscis receptacle near its middle or at least considerable distance anterior to the posterior end 8

8 (9) Anterior and posterior regions of proboscis bearing different numbers of longitudinal rows of hooks.....Genus HETEROPLUS

Twelve longitudinal rows of hooks on the interior region of proboscis, about thirty on posterior. *Heteroplus grandis* (Van. C.) only known species in North America.

9 (8) Anterior and posterior regions of proboscis bearing the same number of longitudinal rows of hooks. Genus MEDIORHYNCHUS..10

10 (11) Proboscis not covered with conspicuous papillæ in which hooks are embedded. Body usually robust, forms with twenty-four longitudinal rows of hooks on proboscis. Embryos 38μ by 16μ..... .....*Mediorhynchus robustus* Van C.

11 (10) Proboscis hooks not conspicuous; embedded in conspicuous papillæ. Eighteen longitudinal rows of hooks. Embryos 38μ to 47μ by 18μ to 24μ.....*Mediorhynchus papillosus* Van C.

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12 (1) Body proper bearing spines, at least in restricted regions.....13

13 (14) Body spines on anterior region of the body and also surrounding genital opening.....Genus CORYNOSOMA, males

But one species, *Corynosoma constrictum* nov. spec., known to North America.

14 (13) With no cuticular spines around the genital opening.....15

15 (26) Anterior end of the body decidedly larger than posterior end.....16

16 (23) Anterior and posterior regions of the body of distinctly different histological structure.....Genus ARHYTHMORHYNCHUS..17

17 (18) Hooks on mid-ventral surface of proboscis conspicuously larger than on any other part of proboscis.....
.....*Arhythmorhynchus trichocephalus* (R. Leuckart)

18 (17) Hooks on ventral surface of proboscis not conspicuously larger than on any other surfaces.....19

19 (20) Longest hooks more than 100μ long.....
.....*Arhythmorhynchus uncinatus* (Kaiser)

20 (19) Longest hooks not more than 50μ long.....21

21 (22) Proboscis with sixteen longitudinal rows of hooks. Embryos 65 to 80μ long, 18μ wide....*Arhythmorhynchus pumilirostris* Van C.

22 (21) Proboscis with eighteen longitudinal rows of hooks. Embryos 76 to 100μ long, 24 to 30μ wide....*Arhythmorhynchus brevis* Van C.

23 (16) Anterior end of body larger than posterior end, but body wall of same histological structure throughout.....24

24 (25) Anterior region of body set off from posterior region by conspicuous constriction. Proboscis cylindrical, or frequently tapering slightly toward base.....Genus POLYMORPHUS

Polymorphus obtusus nov. spec. only species described from North America.

25 (24) Anterior region of body distinctly swollen, but not separated from posterior by a constriction. Proboscis spindle shaped.....
..... Genus CORYNOSOMA, females

Corynosoma constrictum nov. spec., only known species from North America.

26 (15) Body sac-like or sausage shaped, not conspicuously swollen at anterior end. Proboscis spherical or ovate, followed by a neck fully as long as the proboscis and sharply set off from the body proper.
.....Genus FILICOLLIS

Filicollis botulus Van C. is the only species known to North America.

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XV. Summary

1. This article contains the results of a study of the Acanthocephala parasitic in birds from the U. S. Government collections and the private collections of Professor H. B. Ward and of the writer.

2. *Echinorhynchus striatus* taken by Linton from *Oidemia americana* belongs to the genus Corynosoma and here is described as *Corynosoma constrictum* nov. spec.

3. *Echinorhynchus rectus* Linton, 1892 is shown to belong to the genus Plagiorhynchus. *P. formosus* nov. spec. from *Colaptes auratus* is described. These two species constitute the first record of species of Plagiorhynchus in North America.

4. *Polymorphus obtusus* nov. spec. is described from *Anhinga anhinga.*

5. *Polymorphus species?* is recorded from *Lophodytes cucullatus.*

6. *Mediorhynchus papillosus* Van C., 1916 is designated as type of the genus Mediorhynchus.

7. The genus Heteroplus is one of the Centrorhynchidæ (not of the Gigantorhynchidæ as maintained by Kostylew, its creator).

8. *Mediorhynchus grandis* Van C., 1916 is shown to belong to the genus Heteroplus.

9. *Corvus brachyrhynchus* is cited as a new host for *Heteroplus grandis* (Van C.).

10. Among North American birds the occurrence of two different species of Acanthocephala within the same host individual has never been recorded.

11. There is no positive case on record of the occurrence of two different genera of Acanthocephala within the same species of North American bird.

12. Tables are given to show the comparison of acanthocephalan infestation in the families and orders of birds of central Europe and of North America.

13. A key to all described species of Acanthocephala from North American birds is given.

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XVII. Explanation of Plates

All figures excepting Figure 7 are drawn by the aid of a camera lucida from stained specimens mounted in xylol damar. The magnification is indicated by the projected scale accompanying each drawing.

Abbreviations Used

b. bursa copulatorix
br. brain.
c.g. cement glands
e. egg masses
ins. insertion of proboscis receptacle
i.p. invertors of proboscis
l. lemniscus
p.r. proboscis receptacle
r. retinacula
r.p. retractors of proboscis receptacle
t.a. anterior testis
t.p. posterior testis

Plate I.

Figs. 1 to 3, *Corynosoma constrictum* nov. spec.

Fig. 1. Entire male showing general body shape and arrangement of internal organs.

Fig. 2. Posterior tip of male showing cuticular spines.

Fig. 3. Embryo from body of mature female.

Figs. 4 to 6, *Plagiorhynchus formosus* nov. spec.

Fig. 4. Entire male showing general body form and arrangement of internal organs.

Fig. 5. Profile of the proboscis of same individual as shown in Fig. 4.

Fig. 6. Embryo from body of mature female.

Fig. 7. *Plagiorhynchus rectus* (Linton). Drawing copied from Linton 1892.

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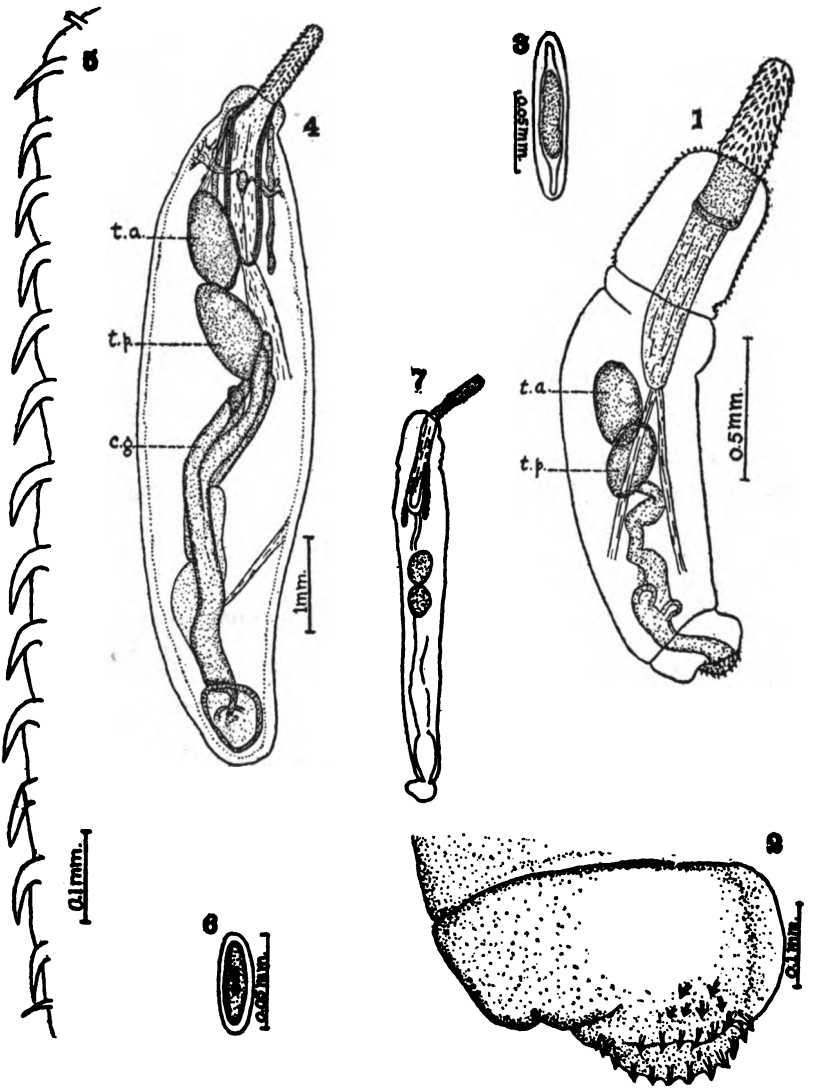

PLATE I.

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PLATE II.

Figs. 8 to 12. *Polymorphus obtusus* nov. spec.

Fig. 8. Entire male, poorly preserved specimen, internal organs very indistinct.

Fig. 9. Cuticular spines in profile, from anterior region of body.

Fig. 10. Embryo from body cavity of female.

Fig. 11. Posterior extremity of type female showing characteristic bluntness upon basis of which the specific name is given.

Fig. 12. Profile of proboscis hooks.

Fig. 13. *Polymorphus species?* from *Lophodytes cucullatus.*

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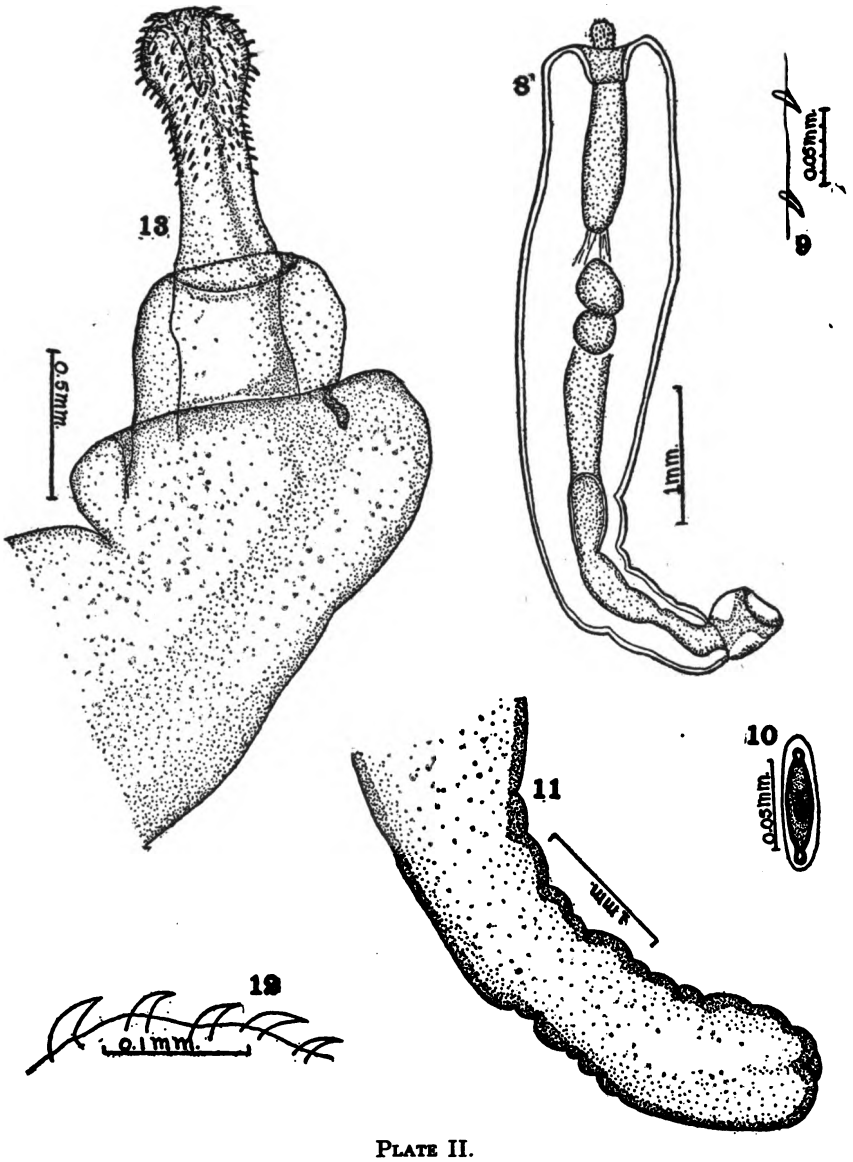

PLATE II.

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PLATE III.

Figs. 14 and 15. *Centrorhynchus spinosus* Van Cleave.

Fig. 14. General body form of type female.

Fig. 15. Profile of dorsal surface of proboscis shown in Fig. 14.

Figs. 16 to 19. *Mediorhynchus papillosus* Van Cleave.

Fig. 16. Entire male showing general body form and arrangement of organs.

Fig. 17. Proboscis and anterior body region of type male.

Fig. 18. Profile dorsal surface of proboscis, same individual as shown in Fig. 17.

Fig. 19. Embryos from body cavity of fully mature female.

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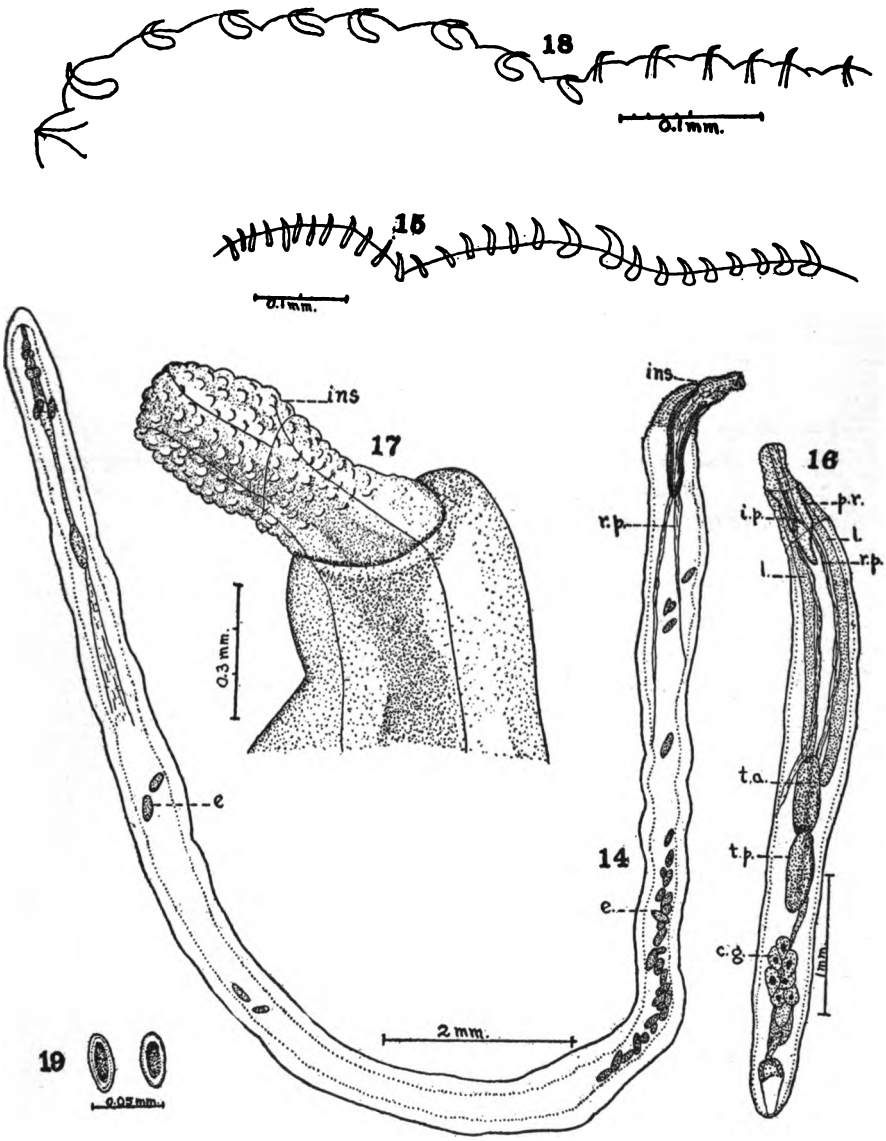

PLATE III.

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PLATE IV.

Figs. 20 and 21. *Mediorhynchus robustus* Van Cleave.

Fig. 20. Male in optical section showing body form and arrangement of organs.

Fig. 21. Embryos from body cavity of mature female.

Figs. 22 to 24. *Arhythmorhynchus brevis* Van Cleave.

Fig. 22. Body of entire male.

Fig. 23. Proboscis and anterior region of body of a male.

Fig. 24. Embryos from body cavity of mature female.

Figs. 25 and 26. *Arhythmorhynchus pumilirostris* Van Cleave.

Fig. 25. Entire male.

Fig. 26. Embryo from body of mature female.

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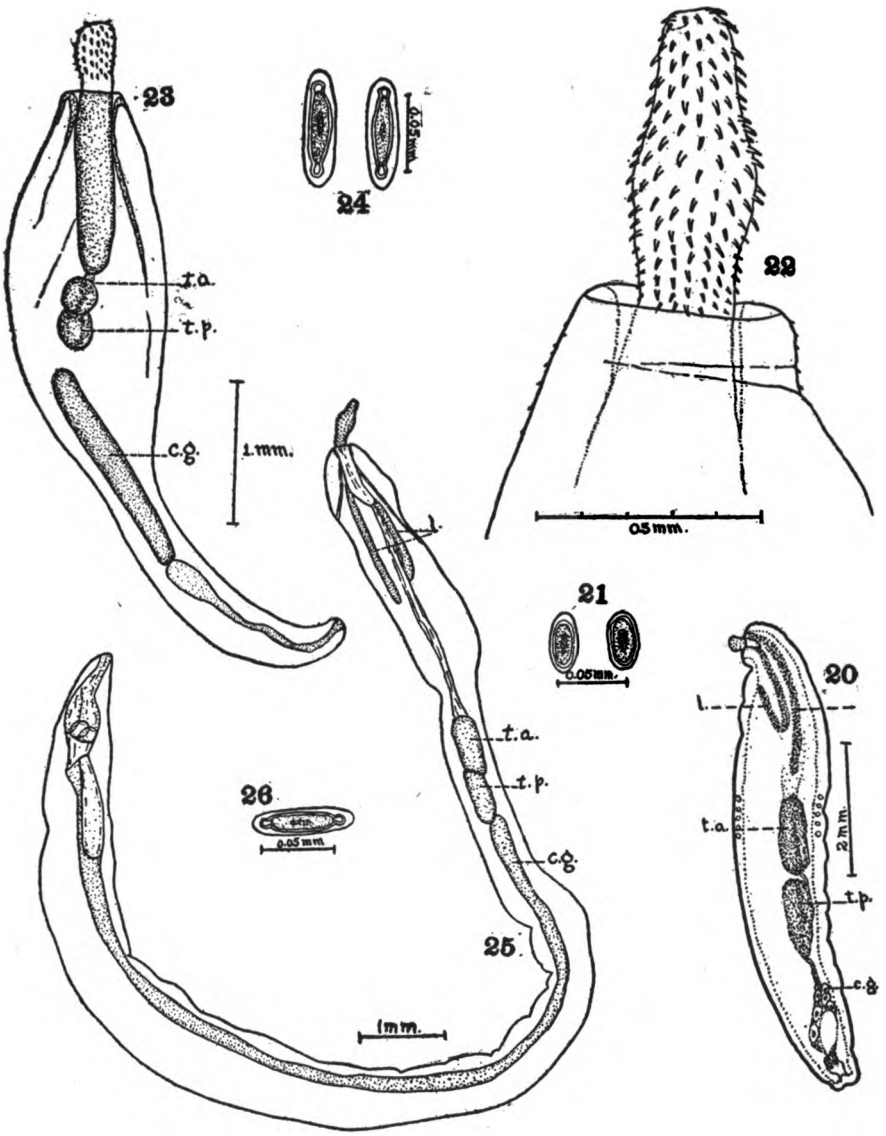

PLATE IV.

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PLATE V.

Figs. 27 to 29. *Heteroplus grandis* (Van Cleave).

Fig. 27. Proboscis partly invaginated, but showing the hook arrangement typical for the genus.

Fig. 28. Embryos from body of mature female.

Fig. 29. Profile of dorsal surface of proboscis.

Figs. 30 to 34. *Filicollis botulus* Van Cleave.

Fig. 30. Entire male showing general body form and arrangement of organs.

Fig. 31. Cuticular spines from anterior region of body.

Fig. 32. Mature female showing general body form.

Fig. 33. Embryo from body cavity of mature female.

Fig. 34. Profile, ventral surface, of proboscis of female.

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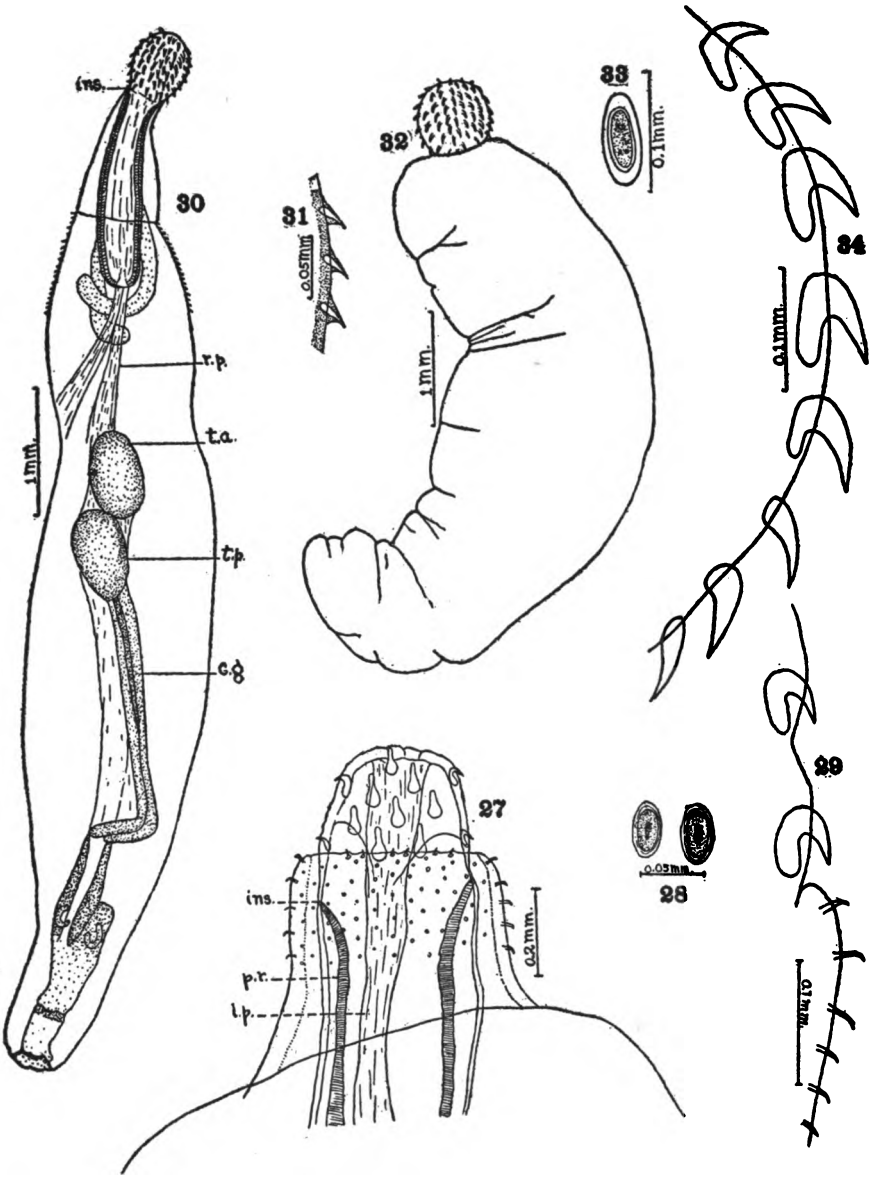

PLATE V.

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BRANCHIOBDELLID WORMS (ANNELIDA) FROM MICHIGAN CRAWFISHES

By Max M. Ellis

Through the courtesy of the Michigan Fish Commission the writer visited several islands in Potagannissing Bay and Lake Huron on Patrol Boat No. 4, Captain Robert E. Ellsworth commanding, during August, 1917. The branchiobdellid worms listed below were taken from crawfishes collected on this trip and from those of two additional collections made by Captain Ellsworth. Dr. Walter Faxon of Harvard University kindly identified the crawfish hosts.

The four species of branchiobdellids represented may be distinguished by the following key.

a. Anterior nephridia opening to the outside through two separate pores in segment III; segments VIII and IX each bearing a pair of glandular disks on the ventral surface; dental formula usually 5-4 or 5-5, the middle tooth of each jaw being the longest tooth in the jaw.
Xironodrilus formosus Ellis *in ed.*

aa. Anterior nephridia opening to the outside through one common pore in the dorsal surface of segment III.

b. Body segments without conspicuously elevated portions; accessary sperm tube present.

c. Upper and lower lips entire excepting a small, median emargination; dental formula 5-4, teeth approaching a subequal condition, although the middle tooth of the upper jaw is distinctly longer than the other four teeth of that jaw.
Cambarincola vitrea Ellis *in ed.*

cc. Upper lip composed of four, subequal lobes, which can be extended as digitiform processes; lower lip composed of two, subequal lobes which can be extended; a small, lateral lobe on each side at the junction of the upper and lower lips; dental formula 5-4; middle tooth of upper jaw long and prominent; lateral teeth small, not more than half the length of the middle tooth.
Cambarincola philadelphica (Leidy)

bb. Dorsal portions of segments elevated; segments VII and VIII with funnel-shaped enlargements of the dorsal portions of the segment, more or less completely encircling the segment; funnel of segment VIII excavated dorsally so that its dorsal margin bears two, small "horns"; dental formula 5-4.
Pterodrilus durbini Ellis *in ed.*

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(1) XIRONODRILUS FORMOSUS Ellis

From *Cambarus virilis* Hagen

1. James Island, Potagannissing Bay, August 4.
2. Three miles up Potagannissing River, Drummond Island, Potagannissing Bay, August 4.
3. Pilot Harbor, Sitgreaves Bay, north side of Drummond Island, Potagannissing Bay, August 6.
4. Little Cass Island, head of Detour Passage, August 6.
5. Churchville Point, head of Lake George, 46° 31′ N., August 7.
6. Harbor Island, Potagannissing Bay, August 8.
7. Winona Slips, Bay City, Saginaw Bay, September (Capt. Ellsworth).

(2) CAMBARINCOLA VITREA Ellis

From *Cambarus virilis* Hagen

1. James Island, Potagannissing Bay, August 4.
2. Three miles up Potagannissing River, Drummond Island, Potagannissing Bay, August 4.

From *Cambarus propinquus* Girard

1. Sault Sainte Marie, St. Marys River, August 7.
2. Echo Lake, Grand Island, Lake Superior, August 17 (Capt. Ellsworth).

(3) CAMBARINCOLA PHILADELPHIA (Leidy)

From *Cambarus virilis* Hagen

1. James Island, Potagannissing Bay, August 4.
2. Pilot Harbor, Sitgreaves Bay, north side of Drummond Island, Potagannissing Bay, August 6.
3. Little Cass Island, head of Detour Passage, August 6.
4. Harbor Island, Potagannissing Bay, August 8.

(4) PTERODRILUS DURBINI Ellis

From *Cambarus virilis* Hagen

1. James Island, Potagannissing Bay, August 4.
2. Three miles up Potagannissing River, Drummond Island, Potagannissing Bay, August 4.
3. Pilot Harbor, Sitgreaves Bay, north side of Drummond Island, Potagannissing Bay, August 6.
4. Little Cass Island, head of Detour Passage, August 6.
5. Churchville Point, head of Lake George, 46° 31′ N., August 7.
6. Harbor Island, Potagannissing Bay, August 8.
7. Winona Slips, Bay City, Saginaw Bay, September (Capt. Ellsworth).

It may be seen from this list that *Xironodrilus formosus* Ellis and *Pterodrilus durbini* Ellis were found in every collection from

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Cambarus virilis Hagen. In each case *Xironodrilus formosus* was the more abundant species, represented by hundreds of individuals. Comparatively few *Pterodrilus durbini* were taken. The relative abundance of these two species may be considered as accurate for these collections as the living crawfish were dropped into the killing fluid as soon as caught, and all of the branchiobdellid worms carried by each crawfish preserved. The two species of *Cambarincola,* if found, were represented by a fair number of individuals. *Cambarincola vitrea* Ellis was the only species taken from *Cambarus propinquus* Girard in these collections. Both species of *Cambarincola* here represented however have been taken from specimens of *Cambarus propinquus* at Douglas Lake, Michigan.

University of Colorado.

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DEPARTMENT OF NOTES, REVIEWS, ETC.

It is the purpose, in this department, to present from time to time brief original notes, both of methods of work and of results, by members of the Society. All members are invited to submit such items. In addition to these there will be given a few brief abstracts of recent work of more general interest to students and teachers. There will be no attempt to make these abstracts exhaustive. They will illustrate progress without attempting to define it, and will thus give to the teacher current illustrations, and to the isolated student suggestions of suitable fields of investigation.—[Editor.]

A CHART ON GENERAL PLANT HISTOLOGY AND PHYSIOLOGY

The valuable teaching aid afforded by charts and diagrams of various sorts is well understood by most teachers of biology who are more or less well acquainted with the numerous current sets of charts offered to the profession. There are a few teachers who possess the enviable talent of rapidly constructing excellent blackboard sketches during a given lecture or laboratory period to illustrate the particular features or phenomena under study at that particular time. Some instructors have made use of the more permanent crayon sketches on sheets of drawing paper hung over an easel. The uses of the various lantern-slide, opaque, vertical and micro-projection possibilities are also utilized to a very desirable degree under certain circumstances.

The principal pedagogical difficulty which all teachers have probably experienced in the practical application of these or other useful adjuncts of the same general kind to teaching is, that at best the student gets a disjointed presentation of the subject in question for the reason that the subject matter must be presented more or less disjointedly and interruptedly because of the many other things which we compel him to study. The student suffers from this regular lack of continuity. He loses much because of his failure to see the real position of a given structure or place of a given activity in the organism as a whole.

I may illustrate my meaning here by a reference to the common practice in teaching some of the phases of botany, say phytohistology. Probably students may be found in every class in plant histology as that subject is currently taught, who, knowing right well the detailed characteristics of all of the common tissues of the vegetable kingdom and how to handle the histological technique involved

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in the preparation of such tissues, may fail utterly to acquire an adequate knowledge of the place and function of those tissues in the plant as a whole. In fact such students may not even know where in the plant to find a given tissue if they are thrown upon their own resources, resources derived from their histology courses. Surely it is most difficult for them to really understand the function of the various tissues of the plant if they do not know the position of the tissues within the plant.

The same general state of affairs sometimes exists in plant physiology. The student may understand the various fundamental processes of the plant very well, but he often fails to read through the whole series of interrelated activities and to visualize, as it were, the individual plant as a completely equipped and working entity.

The most fundamental process in all nature is photosynthesis. Consequently it is quite desirable that the student of general biology, of general botany, surely of general physiology and general science should understand at least the fundamental features and the significance of that great phenomenon. He should know photosynthesis as it occurs in the leaf, of course, but he should also know about many of the other processes and structures which make the photosynthetic manufacture of carbohydrates in the leaf possible. He must know quite well many of the interrelations of the various activities of the plant if he wishes to really understand photosynthesis. He must see the plant as a completely constructed mechanism with its various parts working together in harmony. It is the business of the teacher to see to it that he does get this notion definitely outlined in his mind.

Now to be sure that our students really *get* all of this and this point of view of the plant, requires more than a little thought on the part of the teacher as to the methods of instruction that are to be followed in the class-room and laboratory. Sometimes I have thought that some of the common difficulties in this connection might be lessened if the class were to take a single common plant, say the sunflower, castor bean or scarlet runner, and work out its entire structural and physiological life-history from the embryo in the seed through the development and maturation of the new individual

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including the new fruit and seed. If the exercises on histology and physiology were properly correlated at every point possible I believe that such a method would result in giving to the student an admirable introduction to many of the fundamentals of general botany. At the conclusion of such a course the student would have secured an admirable and useful insight into the most of the important plant phenomena. And I believe that he would actually retain a definite mental picture of what the plant *is* as a *mechanism* and what it *does* as a *living, working* organism. From such a course he would surely obtain a connected view of these matters and he would not think of the plant as composed of a group of parenchyma cells here, a strand of fibers there, an irregular patch of epidermis somewhere else. He would not stop to wonder how and from whence the root gets the necessary food for its growth or how it is possible for growth to begin in a tree in early spring before the leaves have unfolded their chlorophyll-containing tissues.

Something of the same results may be secured by the skillful teacher from a carefully planned summary of the whole matter in which the various interrelations and correlations are plainly worked out. I have found in my own department that generalized drawings aid greatly in connection with such summaries. An illustration which brings before the student by means of a single chart or page many of the essentials has been found most useful by myself and the other instructors in my department. The late Professor Bessey was a master in preparing such diagrams. His specialty was, as all know, the preparation of figures to show lines of descent and evolution of the groups of the plant world. Whether one could agree as to the derivations and progress of evolution represented by his diagrams or not did not detract from the fact that his figures helped greatly to portray the principles and the theories that he wished to emphasize. Thousands of his students were enabled to secure a much better idea as to what evolution really is from such methods even if they went no further in their study of biology than the Freshman course.

Figures or diagrams of this sort may be studied indefinitely and the longer they are examined the more illuminating they become until the average student is enabled to secure a complete and prop-

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THE HISTOLOGY AND PHYSIOLOGY OF THE PLANT

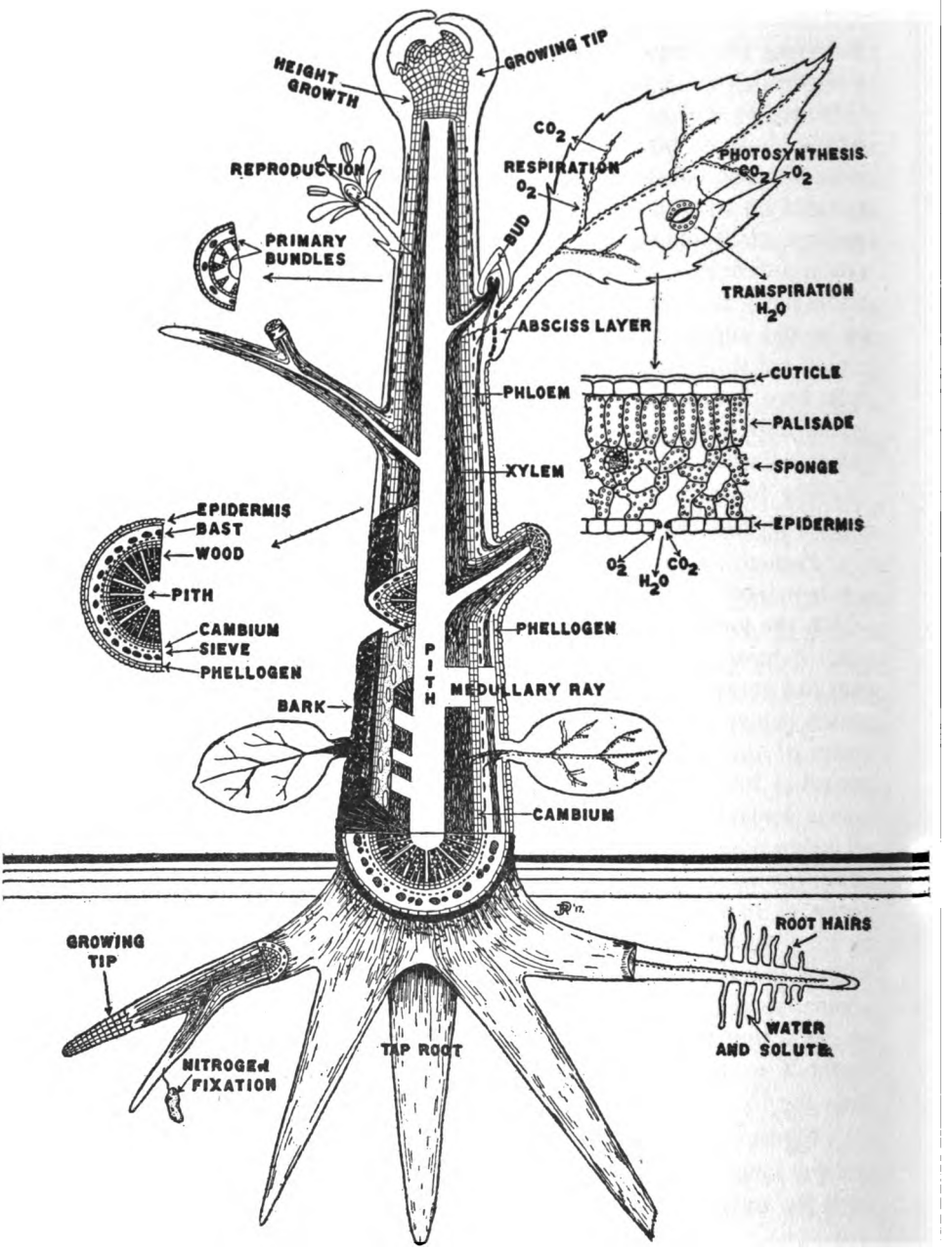

PLATE VI

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erly balanced conception of the chief features of the subject in question.

Such figures may be constructed in great detail and with much technical skill or they may be more or less crude and diagrammatic and still be of great value to the learner. With the information gained from careful studies of plant anatomy and plant processes the student should be able to fill in the missing details of a generalized drawing and to interpret properly the diagrammatic features of the figure. This being possible, a diagram of the kind submitted herewith should be exceedingly helpful and, indeed, illuminating. It was solely because of the success of these methods in this department that I was led to publish these brief notes and the diagram in the hope that they might be suggestive in some degree to my fellow workers in biological fields.

The figure as published here has been revised and redrawn from a similar figure published in 1914 by the writer in a laboratory manual of plant physiology. The older diagram was later enlarged and worked out in the form of a wall chart. The reader will understand, of course, as he looks at this diagram that the relative proportions of the various structures exhibited are not intended to be represented at all as they actually occur in the living plant. In fact the proportions are mostly so unnatural as to be grotesque and even misleading if the student or reader does not understand how to interpret them in the light of what has been said in the above paragraphs. He is supposed to have acquired this understanding in his courses of study dealing with the plant. The figure merely helps him to *see* the *interrelations* of the facts of histology and physiology graphically summarized in the features of the chart. The chart represents in a more or less diagrammatic manner an epitome of the great facts of histology and physiology. Many additional entries might be made upon the chart, but the danger is in so multiplying details that the real purpose of the sketch may be obscured behind the maze of unessential details. That would be a serious blunder in the use of this method of teaching or learning.

I believe that it is one of the chief duties of a teacher to epitomize very carefully his subject as fully as possible by whatever

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methods he may devise. In so far as he is successful in this practice so far will the students in his classes carry away with them a definite and compact and possibly useful body of knowledge upon the subject taught. Such a chart as this has been found very useful in such an epitome, and the method in general is successful in application.

RAYMOND J. POOL, PH. D.

The University of Nebraska.

A METHOD FOR MOUNTING ANATOMICAL PREPARATIONS FOR EXHIBITION

Oftentimes students in comparative anatomy make excellent preparations which are worthy of preservation. But this is not done as a rule because of the trouble in mounting. A glass strip of just the right size to fit into the exhibition jar must be found. The preparation is with difficulty tied by thread to the glass plate. If one could only "pin" into glass! The following method is suggested as a solution. A mixture of hard paraffin, beeswax and lampblack is melted up and poured into a paper box cover about the size needed had a glass plate been used. The mixture in the cover should be between ¼ and ½ inch deep. It should be allowed to cool somewhat and then on this bed the preparation should be placed and pressed down into it somewhat. A few small pins can easily be made to fasten it securely. When the matrix is cooled they can be clipped off on the back. Labels can also be easily attached to parts of the dissection. The entire cover can now be placed in cold water for a few minutes. When hardened the cover can be cut away with a knife—the paraffin background cut down to just the size that will fit into the glass jar—care being taken to make it fit in snugly. The jar can now be filled with formalin and the cover fastened on. The black background makes the objects stand out distinctly and the preparation never becomes loosened from its wax bed. The whole operation takes but a few minutes time.

G. G. SCOTT.

Department of Biology,
College of the City of New York.

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GREEN LIGHT FOR DEMONSTRATING LIVING CESTODE OVA

By projecting the light from a small arc through two screens, one of Picric Acid yellow and one of Methyl Blue blue, a green light was obtained which gave a peculiarly sharp definition to the details of living Cestode ova. The eggs were studied on a slide under either low or high power. This light has been used in connection with the demonstration of the eggs of *Dipylidium caninum, Tænia crassicollis* and *Hymenolepis nana.* The color screens were prepared by staining lantern slide plates, after dissolving out the silver with Hypo from the unexposed plate, in either a weak solution of Picric acid or Methyl Blue. In each case the film was stained until it showed a distinct color when washed in water.

University of Colorado. M. M. ELLIS.

A NEW METHOD OF STAINING TISSUES CONTAINING NERVES

Captain Sydney M. Cone, M. D. (J. Am. Med. Assn., Jan. 19, 1918) proposes the following method for nerves, which he says is excellent in bringing out axis cylinder and medullary sheaths, being approached only by Bielschowsky's Axis Cylinder stain. The latter requires days, and does not give contrast staining.

(1) Harden in 4% formaldehyde for 6 days; (2) carry thru graded alcohols to ether and absolute alcohol; (3) embed in celloidin and cut 10-20 microns, washing in water; (4) stain 15 minutes in carbol fuchsin, washing rapidly in water; (5) place in 1% osmic acid 5 minutes; (6) wash rapidly, and stain for 1 minute in 50% aqueous solution of safranin; (7) place in 1% acid alcohol 1 minute; and in 95% alcohol for 2 minutes; (8) place in absolute alcohol and clove oil alternately until sections appear deep pink and translucent; (9) place in xylene 2 minutes, and mount in Canada balsam.

Paraffin sections sometimes stain fairly well, but it is not safe, as xylene used to remove the paraffin before staining interferes with the process. The formaldehyde hardening is essential for the success of the stain.

[I wonder whether terpineol could not be used here, or bergamot, or naphtha, or even toluol. It would be a good thing if labora-

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tory workers would give the newer results for clearing agents that do not decolorize stains, used after imbedding in (a) celloidin or parlodion, or (b) paraffin.—V. A. LATHAM, Abstractor.]

FONTANA'S SPIROCHETE STAIN

Fontana's method of staining spirochetes involves the use of the following preparations:—1. *Fixing* fluid: acetic acid, 1 c.c.; formalin, 20 c.c.; distilled water, 100 c.c. 2. *Mordant:* tannic acid, 5 gm.; phenol solution (1 per cent), 100 c.c. 3. *Silver solution:* Prepare a 0.25 per cent solution of nitrate of silver, which may be done with sufficient accuracy by dissolving a small crystal in half a test tube of distilled water and adding just enough ammonia solution to cause a slight permanent turbidity. 4. Distilled water.

3. *Process:* Prepare the slide to be stained by spreading the material from the syphilitic lesion very thinly on a clean slide, allowing to dry spontaneously; fix by pouring on the fixing fluid, pouring it off after a few seconds. Renew immediately, and perform this process several times. The total duration of this stage should be *not less* than a minute. Wash well in distilled water, flood with the mordant, apply gentle heat until steam arises, and allow the process to continue for half a minute; wash thoroughly in distilled water (15 to 30 seconds), flood with the silver solution, again warm gently for half a minute, wash, blot and dry. Mount in balsam for permanent specimens. The spirochetes are stained jet black, and appear larger than when stained by ordinary methods. Cedar oil causes the spirochetes *to pale.* V. A. L.

SIMPLE METHOD OF CLEANING OLD USED SLIDES

Johnson (J. Am. Med. A., Dec. 8, 1917) suggests soaking slides indefinitely (24 hours at least) in full strength commercial (household) ammonia, followed by rinsing with water and wiping clean. Stained smears of all kinds, immersion oil, balsam mounts are equally well cleaned. The same supply may be used repeatedly if kept in tightly closed receptacle. V. A. L.

MENTHOL FOR NARCOTIZING

Don't forget that menthol is an effective reagent in narcotizing or anæsthetizing lower forms of life such as Rotifers, Infusoria, or even small crustacea. V. A. L.

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FRESH WATER BIOLOGY

Teachers in America have been eagerly awaiting this volume for several years. The knowledge of the plans of the editors and publishers, including as they have the collaboration of a large number of active biologists, has inevitably become wide spread. The need of such a work, planned on a scale that would be at once liberal and feasible, has been so genuine that it was assured in advance of a very wide use among teachers and working biologists.

The unanimous verdict will be that every reasonable expectation has been met by Professors Ward and Whipple and their helpers, in spite of the fact that the delays inevitable in getting such a synthetic task before the public will cause many of the contributors themselves to feel the need of revising their work by the time of its first appearance. All teachers of Biology, all advanced students of any group, all amateurs who use the microscope on living things, will find "Fresh Water Biology" a necessary part of their equipment.

The volume is, in many ways, very close to the kind of work which has long been fostered and advanced by the American Microscopical Society and its Transactions. An organized interest in limnological work was manifest as early as 1899, at which meeting a Limnological Commission, consisting of Professors Birge, Eigenmann, Kofoid, Ward and Whipple, was appointed to "unify, extend, and stimulate limnological work in this country." The following year this Commission made a report which anticipated much of the ecological work done since with the fresh-water forms of this country, and unquestionably gave inspiration and impetus to the studies on which this book is based. While the volume cannot be listed among the annual *"Transactions"* of the Society, certain it is that much of the contributory work leading to this fine showing in American fresh-water Biology has been done by members of this Society and published in one form or another in its *Transactions.*

So close is this enterprize to what this Society has been encouraging in every possible way for many years, that the pages of the *Transactions* are now freely offered the editor and collaborators,

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pending new editions of the book, for such supplementary and revisional statements as may be necessary from time to time to keep the accounts and keys of the various groups up to date. Such a cooperative arrangement would contribute greatly both to the convenience of our membership and to the most effective use of this manual.

The work is much too compendious and condensed to allow an adequate statement even of its scope, much less to bring to our readers any of its specific contents. In general the material presented is to be classified under three headings: (1) General discussion of the conditions of life and of the effective study of organisms; (2) the biological conditions, method of collection, culture and preservation of the special groups; and (3) systematic keys, with descriptions and illustrations of the classes, orders, families, genera, and representative American species of the groups treated.

Under the first head may be included the introductory chapter by Professor Ward, the chapter on "Conditions of Existence" by Professor Shelford, on "Methods of Collecting and Photographing" by Professor Rieghard, and the concluding chapter by Professor Whipple on "Technical and Sanitary Problems," as related to fresh waters. The biological features of the special groups are treated at the beginning of the appropriate chapters. The chapters on Bacteria, Larger Aquatic Vegetation, and Aquatic Vertebrates are confined to this aspect, making no effort at systematic display.

The following experts furnish the systematic chapters: Edgar W. Olive, Blue-green Algæ; Julia W. Snow, Other Fresh Water Algæ; C. H. Edmondson, Amœboid Protozoa; H. W. Conn and C. H. Edmondson, Flagellate and Ciliate Protozoa; Edward Potts, The Sponges; Frank Smith, Hydra and Other Fresh Water Hydrozoa; Caroline E. Stringer, The Free-living Flatworms; Henry B. Ward, Parasitic Flatworms; Wesley R. Coe, The Nemerteans; N. A. Cobb, Free-living Nematodes; H. B. Ward, Parasitic Roundworms; H. S. Jennings, The Wheel Animalcules; H. B. Ward, Gastrotricha; Frank Smith, Aquatic Chætopods; J. Percy Moore, The Leeches; A. S. Pearse, The Fairy Shrimps; E. A. Birge, The

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Water Fleas; C. Dwight Marsh, Copepoda; R. W. Sharpe, Ostracoda; A. E. Ortman, Higher Crustaceans; R. H. Wolcott, The Water Mites; James G. Needham, Aquatic Insects; Charles B. Davenport, Moss Animalcules; Bryant Walker, The Mollusca.

Two devices in the arrangement of the systematic matter call for comment. The guide numbers in the artificial keys are arranged in accordance with a plan developed by Professors Forbes and Smith at the University of Illinois. Each guide line begins with a number. In addition to its own appropriate number which leads, there follows in parentheses the alternative number (or numbers) which indicates the contrasted line to which the seeker must go if that particular legend is not diagnostic. This is true both of the earlier and the later guide lines in a given series. If a given key line is acceptable the further guiding number is at the close of the line. The device thus gives a perfect system of cross references both forward and backward between categories of a given grade. This is unnecessary in brief keys; but where there are scores of intervening subordinate categories it is a great convenience. The name and description of a species, all the supplementary biological facts concerning it and the illustration are included in a solid panel between its own key line and the next. This gives a convenient compactness which is very satisfying.

The general impression which follows examination of the book is the perfectly enormous amount of material condensed into its somewhat more than 1000 pages. This means, of course, great brevity, and yet no one interested in these groups can feel that the interesting and important matter has been left out. To one whose studies are confined largely to a single group there must come a renewed and enlarged sense of the representative character of the fresh-water organisms. One has brought home to him also the vast incompleteness of our records of the American distribution of even the better known fresh-water species. It ought to be possible in connection with the extended use and further revision of such a work as this to get a better account of specific range in this country.

It seems ungenerous to mention slight imperfections where so much has been brought to our aid. However, the appearance

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of the chapters on Protozoa and Oligochætes is marred by the use of occasional cuts too heavy and opaque to give any true idea of the delicacy of the organisms. Figure 982 of *Chætogaster* is an example of this.

A list of important references, in no case purporting to be a complete bibliography, concludes each chapter. An adequate index, including important descriptive terms and all of the scientific names used in the keys, concludes the book.

Fresh Water Biology, by Henry B. Ward and G. C. Whipple, with a staff of Specialists collaborating. Pages ix and 1111, with 1547 text figures. John Wiley and Sons, New York and London, 1918. Price, $6.00.

AN INTRODUCTION TO THE HISTORY OF SCIENCE

Nothing which has come to the attention of the reviewer puts more convincingly the meaning of the history of science than the preface of this little book by Professor Libby. "The history of science has something to offer to the humblest intelligence. It is a means of imparting a knowledge of scientific facts and principles to unschooled minds.

"The history of science is an aid in scientific research. It places the student in the current of scientific thought, and gives him a clue to the purpose and necessity of the theories he is required to master. It presents science as the constant pursuit of truth rather than the formulation of truth long since revealed; it shows science as progressive rather than fixed, dynamic rather than static, a growth to which each may contribute.

"It is only by teaching the sciences in their historical development that the schools can be true to the two principles of modern education, that the sciences should occupy the foremost place in the curriculum and that the individual mind in its evolution should rehearse the history of civilization.

"The history of science should be given larger place than at present in general history. History of science studies the past for the sake of the future. It is a story of continuous progress. It is rich in biographical material. It shows the sciences in their interrelations, and saves the student from narrowness and premature specialization. It affords a unique approach to the study

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of philosophy. It gives an interest in the applications of knowledge, offers a clue to the complex civilization of the present, and renders the mind hospitable to new discoveries and inventions.

"The history of science is hostile to the spirit of caste. It reveals men of all grades of intelligence and of all social ranks co-operating in the cause of human progress. It is a basis of intellectual and social homogeneity.

"Science is international,—English, Germans, French, Italians, Russians—all nations—contributing to advance the general interests. [The teaching of it] cannot fail to enhance in the breast of every young man or woman faith in human progress and good will to all mankind."

In method, this introduction takes up certain great scientific relations and applications, and treats these largely in connection with the personality of the men who have contributed their solutions. Some of the graphic chapter headings will carry the suggestion of method and of content:—1. Science and Practical Needs —Egypt and Babylonia; 2. Influence of Abstract Thought—Greece: Aristotle; 3. Scientific Theory Subordinated to Application—Rome: Vitruvius; 4. The Continunity of Science—the Medieval Church and the Arabs; 6. Scientific Method; 7. Science as measurement; 8. Cooperation in Science; 9. Science and the Struggle for Liberty; 10. Interaction of all the Sciences; 11. Science and Religion; 12. Reign of Law; 14. Scientific Prediction; 16. Science and War; 17. Science and Invention; 19. The Scientific Imagination; 20. Science and Democratic Culture.

The presentation is simple, direct, vivid, untechnical, and well suited to the intelligent reader with general interests.

An Introduction to the History of Science, by Walter Libby. Illustrated; 288 pages. Houghton, Mifflin Company, Boston, 1917. Price, $1.50, postpaid.

A SHORT HISTORY OF SCIENCE

Evidently the stay and the work of M. Sarton in this country is helping create an atmosphere in which we may prophesy an extension of interest in the history of science. In this atmosphere our own American teachers, who have been doing something in this field for their students, are being encouraged to bring their work to the

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more general audience. All this is very much worth while and will stimulate the giving of similar courses in many of our schools and colleges, both to culture the general student and to unify the scientific consciousness of the student of science.

The book under review is by Professors Sedgwick and Tyler and embodies very largely the well known course of lectures on the subject begun by the senior author in Massachusetts Institute of Technology more than twenty-five years ago. The purpose is expressed by the authors thus,—"To furnish a broad general perspective of the evolution of science, to broaden and deepen the range of the students' interests, and to encourage the practise of discriminating scientific reading, . . . by furnishing the student and the general reader with a concise account of the origin of that scientific knowledge and that scientific method which, especially within the last century, have come to have so important a share in shaping the conditions and directing the activities of human life."

The general treatment is broadly chronological and geographic, —following the origin and rise of the wonderfully varied civilizations of the near-Mediterranean peoples and their distinctive marks upon the progress of knowledge, of its applications, and of the method and spirit which its right pursuit demands of its followers. The chapter headings indicate this phase of the treatment: Early Civilizations; Early Mathematical Science in Babylonia and Egypt; Beginnings of Science; Science in the Golden Age of Greece; Greek Science in Alexandria; Decline of Alexandrian Science; The Roman World,—The Dark Ages; Hindu and Arabian Science; Progress to 1450 A. D.; A New Astronomy and the Beginnings of Modern Natural Science; Mathematics and Mechanics in the Sixteenth Century; Natural and Physical Science in the Seventeenth Century; Beginnings of Modern Mathematical Science; Science in the Eighteenth Century; Modern Tendencies in Mathematical Science; Advances in Science in the Nineteenth Century.

Within these general headings, further analysis and presentation are based upon a combination of biography, the rise and solution of problems, and the discovery of the principles which have proved significant and fruitful. Topics like the following raise the expectations of the reader and indicate the emphasis: Primitive

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Interpretations of Nature; Astrology; Primitive Counting and Geometry; Mathematics in Egypt; the Calendar and Measurements of Time; Greek Mathematics; Pythagoras; Beginnings of Rational Medicine; the Hippocrates; the Sophists; Circle Measurements; Aristotle; Euclid; Archimedes; Earth Measurements; Beginnings of Human Anatomy; Mathematics and Astronomy at Alexandria; Ptolemy; Hindu Astronomy; Arabian Contributions to Mathematics and Astronomy; Renaissance and Sciences; Alchemy; the Compass; Clocks; Textiles; Printing; the New Astronomy,—Copernicus, Tycho Brahe, Kepler, Galileo; Medicine and Chemistry, Anatomy; Vesalius; Higher Algebraic Equations and Symbolic Algebra; Gregorian Calendar; Harvey and Blood Circulation; Studies of the Atmosphere, Barometer, gases; Phlogiston; Beginnings of Chemistry; Bacon and Descartes; and thus on to the great wave of mathematical and natural science discoveries of the eighteenth and nineteenth centuries which cannot even be enumerated here.

The book is enlivened thruout by appropriate quotations from the men who did the work and from appreciative commentators on that work. In a series of appendices are more lengthy documents, —as, the oath of Hippocrates, Dedications by Copernicus and Harvey, Gallileo before the Inquisition, and the like. Appendix I enumerates and discusses briefly some leading inventions of the last two centuries.

The volume closes with a table of the important dates in the history of science and of civilization, a brief list of reference books, and an index. Each chapter closes with a list of references.

The book is attractively made up and printed.

A Short History of Science, by Sedgwick and Tyler. Illustrated, 474 pages. The Macmillan Co., New York, 1917. Price, $3.50.

BIOCHEMICAL CATALYSTS IN LIFE AND INDUSTRY

This volume discusses only the proteolytic enzymes, being the second volume by the author on enzymes and their uses. A preliminary chapter discusses the nature of the transformations that take place in the living cell, the inorganic catalysts, the biochemical catalysts, the theories as to their mode of operation, and a classification of proteolytic enzymes based on the number of molecules of

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water they are capable of fixing in a molecule of albumin. Following Schutzenberger's conception of the structure of the polypeptide molecule, the author presents a very attractive and cogent statement of the mechanism of progressive hydrolysis of these molecules under ferment action.

The general discussion proceeds under these heads:—The *Coagulating Catalysts,*—thrombin, myosinase, and rennet; *Pepsin; Trypsin,* both pancreatic and from various animal and vegetable sources; *Erepsins,* including those secreted in the intestines, the poorly defined peptolytic enzymes which act on so-called peptones, nucleases which transform the phosphoric nucleo-proteins, arginase, and a small group of creatin-destroying catalysts; and the *Amidases,* the group of enzymes which aid in the final decomposition of the amino-acids,—the last stages of the reduction of the protein molecule before assimilation or excretion.

The statement of the nature, origin, mode of isolation, properties, and physiological role of these vital substances is extremely lucid, and meets the need of the general biologist who has not the opportunity to keep abreast with the more technical aspects of this department of biochemistry.

Most general readers will be especially attracted to Part VI, which deals with the applications of these organized catalysts to medicine and industry, together with the grounds upon which such applications are possible. The author traces the use and abuses of pepsin in therapeutics, and progress made in standardizing tests of its efficiency both as to dissolving and in actual peptonizing power. Reference is made to peptones, both peptic and pancreatic, offered as an easily assimilable diet for greatly debilitated patients. Similar preparations are used in making culture broths in bacteriological laboratories.

In a similar way diagnosis of stomach states is made by analysis of the gastric contents at different stages of test meals, with a view to obtaining the amount of chemical change, the acidity, and the enzymic contents. The author holds that the disrepute into which this determination has fallen is due to poor methods of application rather than to any fault of the principle itself.

In preservation and use of grains and flours native proteolytic

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enzymes, and those produced by micro-organisms on the surface of the grains or placed in the flour purposely, bring changes that must be considered. So in brewing and in grain distillation, these biological catalysts play an essential role. The same processes are seen in the milk ferments and in the ripening of cheeses. In the latter some of the enzymes are native to the milk, some are produced by micro-organisms, and rennet is added artificially.

There is an interesting discussion of the relation of the proteolytic milk ferments to intestinal putrefaction. The writer himself has done work with the Bulgarian ferment, and his views as to the cause of the benevolent intestinal action of the various clotted milks are contrasted with those of Metchnikoff and others.

Other topics discussed are:—putrefaction, enzymes operative in tanning, biocatalysts of the soil, assimilation of atmospheric nitrogen, fertilizers, recovery of nitrogenous wastes, and artificial nitrogenous foods.

As the outcome, largely, of his own experiments the author sums up his conclusions in respect to the last item thus:—"It appears that there is ample proof that the organism draws all its nitrogenous constituents from the hydrolysis of proteins. These may result either from the actual process of digestion, or from artificial means, like the action *in vitro* of proteolytic enzymes or the action of concentrated acids. In all events, these [artificially reduced nitrogen molecules] are directly assimilable substances and should be considered as food materials of great nutritive value.

In fact, it has been established that a mixture of amino-acids, containing qualitatively and quantitatively all the principal products of the complete hydrolysis of proteins, can replace the albuminoid foods, and as such maintain the animal organism in nitrogenous equilibrium." The writer is convinced that nutrition can ultimately be effected more economically and rationally by the substitution of some of these artificially produced nitrogenous foods for the complex natural ones, such as meat.

Each chapter is followed by a bibliography; and an index closes the book. The mechanical part is well done.

Biochemical Catalysts in Life and Industry, by Jean Effront. Translated by Samuel C. Prescott, 752 pages. John Wiley and Sons, New York, 1918. Price, $5.00, postpaid.

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PROCEEDINGS

of the American Microscopical Society

MINUTES OF THE PITTSBURG MEETING

The thirty-sixth annual meeting of the American Microscopical Society was held in affiliation with the A. A. A. S. at Pittsburg, Pa., Dec. 29, 1917.

In the absence of President Guyer, Vice-President Griffin acted as chairman.

The report of the Custodian was presented and was accepted, ordered printed and referred for audit to a committee consisting of Professor Griffin and any other Pittsburg members whom he might select.

The Treasurer's report for the years 1916 and 1917 was accepted and referred to an auditing committee consisting of Drs. Latham and McCalla of Chicago.

The Society approved the recommendation of the Treasurer that the fiscal year be regarded as extending from Dec. 1 to Nov. 30.

The following officers were duly nominated and elected for the constitutional periods: President, Professor L. E. Griffin, University of Pittsburg; First Vice-President, Dr. H. M. Whelpley, St. Louis; Second Vice-President, Professor C. O. Esterly, Occidental College; Secretary, T. W. Galloway, Beloit College (for two years); Custodian, Magnus Pflaum, Esq.

In connection with the re-election of Mr. Pflaum it was noted that he has been custodian for eighteen years continuously since the formation of the office, having been Treasurer for three years before. A cordial vote of appreciation was extended him for this long and efficient service.

Professor Max M. Ellis of University of Colorado and Professor J. E. Ackert of Kansas State Agricultural College were chosen as the elective members of the Executive Committee for 1918.

Professors Griffin and Galloway were appointed a committee to approve and print the minutes. Adjourned.

T. W. Galloway, *Secretary.*

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SPENCER-TOLLES FUND

Custodian's Report for the Years 1916 and 1917

Amount reported in 1915		$4489.32
Jan. 1, 1916, Dividends	$ 134.67	
July 1, 1916, Dividends	138.69	
Dec. 6, 1916, Sale of Transactions	60.00	
Dec. 15, 1916, Sale of Transactions	60.00	
Dec. 31, 1916, Dividends	142.86	536.22
		$5025.54
July 1, 1917, Dividends	$ 150.75	
Dec. 31, 1917, Dividends	155.28	306.03
		$5331.57

GRAND TOTALS

All Contributions	$ 800.27	
All Sales of Transactions	878.38	
All Life Memberships	300.00	
All Interest and Dividends	3542.92	$5521.57

LESS

All Grants	$ 150.00	
All Dues on Life Members	40.00	190.00
		$5331.57

Life Members: (Robert Brown, dec'd); J. Stanford Brown; Seth Bunker Capp; Henry B. Duncanson; A. H. Elliott; John Hately.

Contributors of $50 and over: John Aspinwall; Iron City Microscopical Society; Magnus Pflaum; Troy Scientific Society.

MAGNUS PFLAUM, Custodian.

Pittsburgh, Pa., Dec. 29, 1917.

We, the undersigned committee, hereby certify that we have carefully examined the above account for the years 1916 and 1917 and found the same correct.

L. E. GRIFFIN, Chm. Auditing Committee.

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ANNUAL REPORT OF THE TREASURER OF THE AMERICAN MICROSCOPICAL SOCIETY

December 24, 1915, to December 24, 1916

RECEIPTS

Balance on hand from 1915	$ 476.65
Membership dues	532.10
Initiation fees	129.00
Subscribers	302.20
Sales of Transactions	150.40
Advertisers	184.90
Miscellaneous	2.68
Total Receipts	$1777.93

EXPENDITURES

Printing Transactions, volume 34, no. 4	$ 269.28
Printing Transactions, volume 35, nos. 1, 2, and 3	592.13
Plates for Transactions, volume 34, no. 4	8.91
Plates for Transactions, volume 35, nos. 1, 2, 3 and 4 (in part)	74.92
Advertising literature	37.00
Office expenses; stenography, supplies, etc.—	
Secretary	134.59
Treasurer	26.70
Postage and express—	
Secretary	109.78
Treasurer	31.90
Mailing Transactions	16.16
Spencer-Tolles Fund from sales of sets of Transactions to U. of Pa. and to Notre Dame U.	120.00
Purchase of partial sets of Transactions	45.50
Expenses of Secretary at Columbus meeting, 1915	31.65
Sundry	5.70
Balance on hand	273.71
	$1777.93

Respectfully submitted,

H. J. Van Cleave, Treasurer.
Feb. 15, 1918.

We hereby certify this statement corresponds with the Treasurer's book.

V. A. Latham,
George Edward Fell,
Auditing Committee.

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ANNUAL REPORT OF THE TREASURER OF THE AMERICAN MICROSCOPICAL SOCIETY

For the year beginning Dec. 25, 1916, and ending Dec. 21, 1917

RECEIPTS

Balance on hand from 1916	$ 273.71
Membership dues	880.00
Initiation fees	42.00
Subscribers	119.80
Sale of Transactions	174.00
Advertisers	435.00
Partial payment for cuts	23.14
Total receipts	$1947.65

EXPENDITURES

Printing Transactions, volume 35, no. 4	$ 259.28
Printing Transactions, volume 36, nos. 1, 2, and 3	543.74
Plates for Transactions, volume 35, no. 4	29.64
Plates for Transactions, volume 36, nos. 1, 2, 3, 4	78.35
Postage and Express	75.42
Office expenses—	
Secretary	73.37
Treasurer	32.26
In part payment of Secretary's expenses to Pittsburg meeting	50.00
Binding set of Transactions for sale	20.00
Miscellaneous items	16.02
Balance on hand	770.57
	$1947.65

Respectfully submitted,

H. J. Van Cleave, Treasurer.
Feby. 15, 1918.

We hereby certify this statement corresponds with the Treasurer's book.

V. A. Latham,
George Edward Fell,
Auditing Committee.
Feb. 12th, 1918.

I hereby certify that I have examined the vouchers and accounts of H. J. Van Cleave, Treasurer American Microscopical Society, for the period ending Dec. 21, 1917, and I find the balance of $770.57 as shown on the books to be correct.

F. S. Johnson, Public Accountant.

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